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MINERAL RESOURCES.

No. 12.

Engineering  
ENGINE STORAGE  
REPORT

ON THE

DRAKE GOLD AND COPPER FIELD.

BY

E. C. ANDREWS, B.A.,

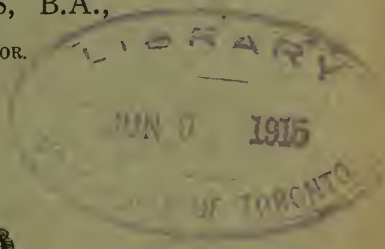
GEOLOGICAL SURVEYOR.



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## INTRODUCTION.

ACTING under instructions from Mr. E. F. Pittman, Government Geologist and Under Secretary for Mines, a geological survey of the Drake Mining Field was made by me during the spring of 1904. On the trip I was accompanied by Mr. M. Morrison, Senior Field Assistant.

It is a difficult area to map accurately, *i.e.*, in which to supply a connected sequence of geological events. Instead of containing several strong lines of rock junctions, whose succession in time might thus be readily grasped, it consists of a mass of insignificant and overlapping lava flows, sandwiched in with which are certain fossil beds. Dense jungle growths are common, which still further complicate mapping work.

Several of the lava outcrops in this rough country were mapped in by Mr. Morrison, during my temporary absence in New England.

Drake, at present, is a very neglected field, a fact due, in great measure, to its complicated and minute structures.

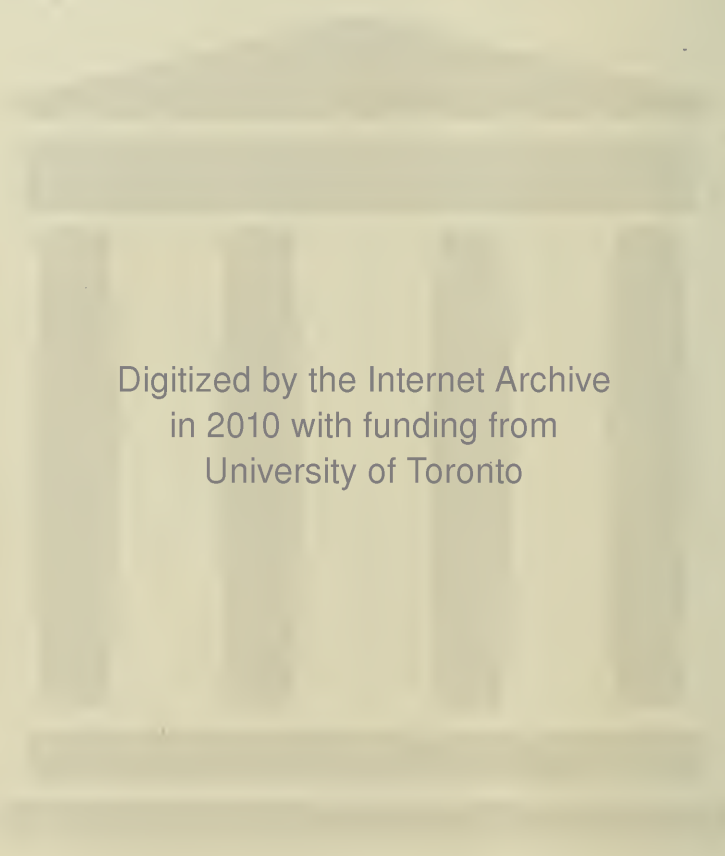
I am greatly indebted to Mr. J. P. Curran, J.P., Mining Registrar of Drake, who from his great local knowledge has supplied me with the historical notes of the field. These notes have been adopted almost word for word in the chapter on the history of Drake. The Notes on the Boorook and Lunatic Reefs have been also supplied by Mr. Curran.

To Mr. L. Gundlach, L.S., my best thanks also are due for notes on the White Rock ore and metallurgical processes, also for details of the Adeline property.

I desire, also, to record my thanks to Mr. D. Cullen, Mr. Edgar Hall, Mr. Thos. Horton, Mr. J. P. Curran, Mr. Arthur Smith, Mr. Clarence Smith, and Mr. J. Thomas (Rivertree), for pointing out to me the various fossil beds of the Drake district. Mention of these fossil finds will be made in their proper place in the chapter on the general geology of the field.

The Permo-Carboniferous age of the strata described in the report was determined by Mr. W. S. Dun, Palæontologist to the Survey.

The maps and sections were prepared by Mr. O. Trickett, L.S.



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# REPORT

ON THE

## DRAKE GOLD AND COPPER FIELD.

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### History of the Field.\*

IN 1878 silver was discovered at Boorook by the late Mr. Thomas Horton, in the Golden Age Mine, which was, possibly, the first deposit of silver ore worked at a profit in New South Wales.

Mr. Horton, for about three years, endeavoured to extract the metal from the ore with very primitive appliances only, and was partially successful whilst operating on the oxidised belt of mineral which extended to a depth of 80 feet from the surface. Below that depth, however, when the sulphides came in, chlorination furnaces were erected. At this juncture Mr. Wesley Hall purchased the mine, and with the assistance of Mr. Benjamin Davey, an experienced metallurgist, erected furnaces and other machinery for the proper saving of the metal. Successful extraction was thus carried on for a further period of three years.

The main shaft on the mine was sunk to a depth of 320 feet. At the 150-foot level a large bunch of sulphide ore was met with. This in its widest part was 19 feet, and averaged 40 oz. of silver per ton.

In 1886 the Adeline Mine, at Drake, was discovered by one named Costa, who, *en route* to Casino, camped near the site of the present Adeline workings. Noticing some peculiar appearance in the rock on the side of a neighbouring slight rise, a miner's curiosity induced him to examine the stone, which outwardly resembled specimens he had seen at Mount Morgan. On crushing the sample he found unmistakable indications of a valuable deposit of gold. Further search enabled him to locate the Adeline Reef. This mine has since been worked with varying success. Both gold and copper are won from this property.

The discovery of the Adeline gold gave a great local impetus to prospecting, and the precious metal was rapidly discovered in various places on Mount Carrington, known formerly as Mount Pleasant.

The Mount Carrington Mine, situated on the crown of the mountain, was the first to come into prominence. It passed out of the hands of the original prospectors, and has since produced a large quantity of gold.

The Pioneer Mine was one of the most important lines of reef on this hill. It has furnished employment to a large number of miners, and has also yielded important gold and copper values.

The All Nations Mine was also discovered during this prospecting campaign. It occurs on the northern side of the hill (Carrington), on the slope into Sawpit Gully. For several years it yielded fair quantities of gold, while mining operations were confined to the oxidised belt.

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\* Being notes supplied by Mr. J. P. Currant J.P.

The Lady Mary is another mine, on the northern slope of Mount Carrington, which has yielded a considerable quantity of gold and copper.

Lower down Sawpit Gully a large formation containing gold and silver in small quantities was held by the Sawpit Gully Gold and Silver Mining Company. For the purpose of working this low-grade ore reduction works, costing several thousands of pounds, were erected. The ore treated was reported to be worth 26s. per ton, from a lode 33 feet wide at the 100-foot level. The treatment was, however, unsuccessful.

Following on the discovery of gold in the localities mentioned, prospecting operations were extended to more outlying areas. Red Rock, 10 or 12 miles from Drake, in a north-westerly direction, was thus discovered. The lodes in this locality are numerous, but their gold values are poor—9 dwt. to the ton being about the highest known yield. In the Red Rock Company's mine a large deposit of zinc was met with at the 100-foot level.

The ore (zinc) is of fair quality, and can be concentrated up to 60 per cent. metal.

The White Rock Silver-mine was the next discovery in the same year, (1886) by Mr. Rossiter and Mr. T. Horton. For a time it was thought by many that its fame would eclipse that of Broken Hill.

To the south of Drake the Mascotte Mine was discovered soon after the finding of the Adeline by Costa. A rich bunch of sulphide ore was passed through from the surface to a depth of 60 feet. Sinking was then carried to a depth of 200 feet, but nothing of value was encountered.

Several parties have worked this mine from time to time. The ores won contain both gold and silver values.

Seven miles south of Drake one comes on the Lady Jersey Mine. This is a peculiar formation and cannot be said to be a defined lode,\* but is rather a series of pockets of zinc blende mixed with quartz containing gold. In the majority of instances the larger bunches of zinc yielded the best gold values. During the past fifteen years this mine has yielded gold of the value of £59,612.

The value of gold and other minerals (silver, copper, lead, and zinc) produced in the Drake district from 1887 to date amounts to £250,000.

## Physical Geography.

Drake lies on the coastal fall of New England, and is distant 511 miles from Sydney, *via* Tenterfield. It is distant 73 miles by road from Lismore, and 33 miles from Tenterfield. The altitude is about 1,650 feet above sea-level, and 1,200 feet below the plateau town. The road connecting the town with the table-land is good, but hilly owing to the presence of several intervening north and south subsequent valleys. The track winds round one of the magnificent gorges, cut by the Cataract River, which, for a considerable distance, has its channel confined to the line of granite and slate junction occurring at this point. The side of the gorge opposite to that in which the road is cut is about 1,700 feet above the channel base, and is crowned in one place with a magnificent and, up till the present, inaccessible granite tor. In former times the granite forming the plateau was much higher than at present, and the present grand block represented a hard kernel from which the softer rock had been removed long since by stream action.

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\* The shafts are at present full of water, but the occurrence appears to be a replacement of country by ore and gangue from an insignificant fissure.—(E.C.A.).

Drake itself, as seen from the main road, does not present a rough topography to the casual traveller. The country to the south of White Rock, however, rises to a height of 1,700 feet above the town, and is intersected by a network of deep ravines, whose precipitous sides are covered with magnificent forest—tall softwood jungle (“brush”), and dense undergrowths of ferns and vines. Blue gums (*Eucalyptus saligna*) attain altitudes of 250 feet, while red mahoganies (*E. resinifera*), scrub boxes (*Tristania conferta*), and blackbutt (*E. Andrewsi*) reach heights ranging between 150 and 200 feet. Cedar-log, Plumbago, and Bullock Creeks also contain patches of magnificent softwood “brush.”

On the remainder of the area forests of tallow-wood, white and red stringy-bark, red and grey ironbark, grey and yellow box, red gum, grey gum, spotted gum, white mahogany, and forest oak abound. From these a plentiful supply of wood for mining and furnace purposes is procurable.

The rainfall is about 40 inches.

The summer heat is rather oppressive, the thermometer at times exceeding 110° Fah. in the shade. The winters, however, are mild, 10° of frost being exceptional.

The question of the evolution of the topographic forms around Drake will be considered briefly under the head of geology.

### General Geology.

The results of the Indian, South African, and Australian geological surveys reveal the existence of great geographical changes during the Permo-Carboniferous period. Professor David\* has worked out the details of the Permo-Carboniferous history as recorded in the Maitland rocks of New South Wales. Two great periods of marine sedimentation are indicated for this district, each alternating with an important set of Coal Measures. Lower and Upper Marines are the names given to these marine sediments, and they total some 10,800 feet in thickness. Each was accompanied by a great Ice age. Doubtless great elevations allowed of these enormous accumulations of marine strata, and they also may be in great measure responsible for the glacial or floating ice masses.

Post-Palæozoic movement in the Maitland district has been confined to vertical movements, to block faulting, and to local igneous intrusions.

A study of the Drake area, several hundreds of miles north of Maitland, shows an equally interesting set of geographical conditions during the same period. After the deposition of the Marines and the Coal Measures, tangential thrusts brought about a mountain-making period. Repeated plutonic intrusions resulted from this folding; decreasing basicity characterising the granite massifs. The igneous cycle closed with the intrusion of numerous basic dykes, and these are associated with the main gold, copper, and silver deposits of New England.

To explain these points more clearly, the narrative style will be followed in describing the Drake geology.

In the year 1900 the Writer was shown a small patch of fossil slate by Mr. D. Cullen, of Undercliff Station. The occurrence was about a mile from the head station. The slate was intensely indurated (silicified) by reason of the net-

\* David, T. W. Edgeworth: The Geology of the Hunter River Coal Measures. Memoirs, Geological Survey of New South Wales,—Geology, No. 4.

work of granite veins traversing it. The fossils collected during that visit have been pronounced to be Permo-Carboniferous by Mr. W. S. Dun, Palæontologist to the Survey.

The following list embraces the fossil types collected at Undercliff :—

*Deltopecten illawarrensis*, Morris.

*Productus subquadratus* (?).

*Spirifer*, *sp. ind.*

*Martiniopsis subradiata*.

*Strophalosia Jukesi*.

*Protoretzpora*.

Here, then, at Undercliff, it appeared that the granites considerably post-dated one phase of later Permo-Carboniferous sedimentation.

Mr. E. F. Pittman, Government Geologist of this State, had, however, at a much earlier period discovered the intrusion of Permo-Carboniferous Coal Measures by granite along the north-western slopes of New England. The following extract from his report of 1896\* may be quoted in this connection:—

“The Ashford Coal Measures are bounded on the west (along the greater part of their length) by a belt of intrusive granite, and this feature is of special interest, because the preponderance of the evidence appears to me to indicate that the intrusion occurred after the deposition of the Permo-Carboniferous Coal Measures.

“The coal bears evidence of having been considerably altered. The lowest portion of the seam has a highly lustrous anthracitic appearance. . . . Moreover, the upper portions of the seam present a dull semi-coked appearance. . . . It is, of course, possible that the intrusion of the granite may have occurred prior to the deposition of the Coal Measures, and that the inclined position of the latter may be due to a fault along the eastern side of the granite. This supposition, however, would not account for the alteration in the character of the coal, and I am, therefore, inclined to think that the former hypothesis is the more correct one.”†

Shortly afterwards a visit was paid to the Undercliff graphite deposits. These were found to be merely a series of dirty coal-seams associated with sandstones and slaty sandstones, the coal having been changed to graphite‡ by the action of an associated coarse granite. The strata were dipping at an angle of about 45°, and were simply surrounded and intruded in all directions by a granite similar to that which had been seen traversing the Undercliff Permo-Carboniferous slates.

The graphite beds appeared to belong to the same series as the fossiliferous strata of Undercliff§, being separated therefrom by a continuous belt of coarse acid granite, some four or five miles in width.

This granite also, during these observations, was seen to possess an extensive horizontal range, inasmuch as it formed large plateaus around Boorook,

\* Records Geol. Survey New South Wales, 1896-98, V, pp. 26-30.

The observations herein set forth by Mr. Pittman came under the writer's notice only after the preparation of the Drake report; otherwise attention would have been directed to them in previous papers dealing with the granite intrusions of New England, e.g. :—

Records Geol. Survey New South Wales—

Tertiary History of New England. 1903. Vol. VII, pp. 194, 195.

The Geology of the New England Plateau. Pt. I, 1904. Physiography, pp. 298, 299.

Do do do do Pt. II, do pp.

Do do do do Pt. III, do pp.

† Prof. T. W. E. David also discusses the probable intrusion of the Ashford coal (Permo-Carboniferous) seam by granite, but owing to the lack of definite criteria of intrusion, he suggests faulting of earlier granites against the Permo-Carboniferous as a probable explanation of the occurrence. (Presidential addresses, Proc. Linn. Soc. N. S. Wales, 1893, also plate.)

‡ E. C. Andrews, Ann. Rept. Dept. Mines for 1901, p. 170.

§ By an oversight in the above-mentioned report, the word *Carboniferous* was employed instead of *Permo-Carboniferous*.

Boonoo Boonoo and Wilson's Downfall. Its great extent, and the fact that it had intruded the Permo-Carboniferous slate *after folding* had taken place (the lines of folding being cut clean across), now indicated that a great period of mountain-making had closed the Permo-Carboniferous sedimentation, and that one *at least* of the typical New England granites had made its appearance during the closing phases of this mountain-making movement.

Early in 1901, when visiting New Koreelah\*, *via* Acacia Creek, and also when passing through Marylands and Cherry-tree Hill Railway Stations (Queensland), opportunity was afforded of seeing Mesozoic sandstones and conglomerates, also strata most probably referable to our "chocolate shales," reposing *on old granite surfaces*. This granite was afterwards seen to be continuous with the Undercliff variety under discussion.

The area of these rocks could as yet only be faintly hinted at. To the east and north-east, along the Tweed and Richmond Rivers, as also still farther south along the Clarence, Bellinger, Nambucca, and Lower Macleay, lay a marvellously crumpled† Palæozoic complex. To the north, between Marylands, Warwick, and the New South Wales border, lay other and similar masses. Owing to the great covering of Mesozoic conglomerates and sandstones, as also the Tertiary basalts, pitchstones, and other products of volcanism—all horizontally bedded,—the meeting ground of the two Palæozoic divisions could not be located.

Again, to the north and north-west, lay a belt of granites, varying in character, whose relative ages had not yet been ascertained. Huge masses of felsites, felspar-porphyrries, and "blue granites," also abounded here. To the more immediate south lay the slates and felsites of Drake, still not correlated, while east and north-east of Drake were great masses of folded slates. At Drake the strata had been thrown into gentle folds only, while those some miles east possessed an almost vertical inclination.

In 1902, while at Drake, the Writer met Mr. Edgar Hall,‡ and through his kindness was enabled to secure a collection of Permo-Carboniferous fossils from the locality.

The following is a list of the fossil types secured on that occasion:—

*Martiniopsis subradiata* var. *deltoidea*, Eth. fil.

*Fenestella*.

*Strophalosia Jukesii*, Eth. fil.

*Productus (undatus ?)*.

*Spirifera Stokesi*, Konig.

*Zaphrentis*.

*Stenopora* (dendroid form).

*Trachypora Wilkinsoni*, Eth. fil.

Encrinite stems and plate impressions.

*Hyalostelia* (cast of spicules).

*Entolium*.

*Modiola*.

*Aviculopecten* (new species).

*Orthoceras*.

\* Thirty miles north of Undercliff.

† The shore-line between Port Macquarie and Trial Bay furnishes magnificent studies in this rock conformation.

‡ In 1899 Mr. Edgar Hall had shown the Drake fossil area to Mr. J. A. Watt, formerly of the New South Wales Geological Survey. The specimens forwarded by him to this Department had been, at that time, pronounced Permo-Carboniferous by Mr. W. S. Dun.

Next, at Rivertree, Permo-Carboniferous fossils were obtained in folded slates. About this time large fossiliferous areas in folded slates were examined at Rivertree (Cullen's Creek). Associated with them were limestone and conglomerate deposits.

The following is the fossil (Permo-Carboniferous) list:—

- Spirifera*, n. sp.
- Fenestella fossula*, Lonsd.
- „ *internata*, Lonsd.
- Crinoid stems.
- Pleurophorus*.
- Trachypora* (?).
- Spirifera vespertilio*, G. B. Sby.

An extremely interesting observation was here made. The coarse granite observed at Undercliff extended to Rivertree, and, in this locality, also intruded the Permo-Carboniferous slates. It in turn, however, cut across a dark plutonic granite, heavily charged with biotite flakes. The latter rock also intruded the Permo-Carboniferous slates. Both of these were penetrated by other granitic types, as also by still later and large eurite dykes. Last of all in this order came a series of *dioritic* dykes, accompanied by well-defined silver veins of great length. This pointed conclusively to the fact that some of our northern New England granites were referable to extremely-late or even post Permo-Carboniferous age, and also that many of the New England mineral fields might require placing in the early Mesozoic period.\* The granites themselves appear to be merely expressions of relief of pressure by the mountain making, and the dioritic dykes and later introduction of mineral deposits point to the closing stages of the great granite period.

The following fossils, of Permo-Carboniferous types, were secured on the occasion of a later visit to Boorook:—

- Trachypora Wilkinsoni*, Eth. fil.
- Crinoid stems.
- Fenestella fossula*, Lonsd.
- „ *internata*, Lonsd.
- Stenopora*.
- Productus* (? *subquadratus*).
- Strophalosia*.
- Martiniopsis subradiata*, G. B. Sby.
- Aviculopecten* (2 sps., both new).

The presence, in great abundance, of *Trachypora Wilkinsoni* is interesting as indicating probably the late Permo-Carboniferous age of these beds. The slates and tuffaceous rocks are gently folded and intruded to the immediate west by a great coarse acid massif. In this locality huge masses of spherulitic rhyolites underlay the slates. One of the sheets, by reason of its superior resistance to the influences of stream-cutting and weathering, has given rise to the "Boorook Falls;" thence, following the Cataract River for miles downstream, the banks of the stream are seen to consist of high and almost impassable slopes of felsite breccias and lavas. Along the main road from Boorook to Drake the cuttings are mainly in the folded fossiliferous slates

\* The Mesozoic, as we see it, sitting on the granite surfaces points to an advanced stage in Mesozoic denudation, for it (the Mesozoic) was initiated by the Permo-Carboniferous folding, and the wearing down of the mountain ranges so as to form a granite plain at sea-level must have occupied a long period of time.

and tuffs, but along the lower "bridle track," connecting the two places, the scouring action of the Cataract, Crooked, Slaty, and Girard's Creeks, has exposed the underlying felsites\* and breccias leaving the slates as huge cappings to the volcanics in the interstream areas.

During the next two years other patches of fossils were obtained at various times in the Drake district.

The following are the fossil types of Crooked Creek ;—

*Internal and external casts of—*

*Stenopora* (small dendroid form).

*Fenestella fossula*, Lonsd.

„ *internata*, Lonsd.

„ (? sp.).

*Protoretepora* (n. sp.).

*Penniretepora grandis*, McCoy, (De Koninck).

Crinoid stems.

*Hyalostelia*.

*Productus subquadratus*, Morris.

*Martiniopsis subradiata*, Sby.

*Spirifer vespertilio*, G. Sby.

*Aviculopecten squamuliferus*, Morris.

„ *elongatus*, McCoy, De Kon.

*Stutchburia compressa*, Morris (?).

*Permo-Carboniferous*. (? Lower Marine or amalgamation of Lower and Upper Marine, W. S. Dun.)

Fossils collected from Jump-up Hill, some 12 miles east of Drake township :—

*Strophalosia*, sp. ind.

*Productus subquadratus*, Morris.

† *Spirifera*, cf. *lata*, McCoy.

„ sp. nov.

„ cf. *Strzeleckii*, Morris.

† *Reticularia*, cf. *lineata*, Martin.

† *Fenestellidæ*.

*Aviculopecten*, cf. *Mitchelli*, Eth. fil. and Dun.

The fossiliferous slates at Drake had been observed to be gently folded only. Towards Jump-up, however, the strata possessed a vertical dip ; thence to Pretty Gully the dip fell to 40°.

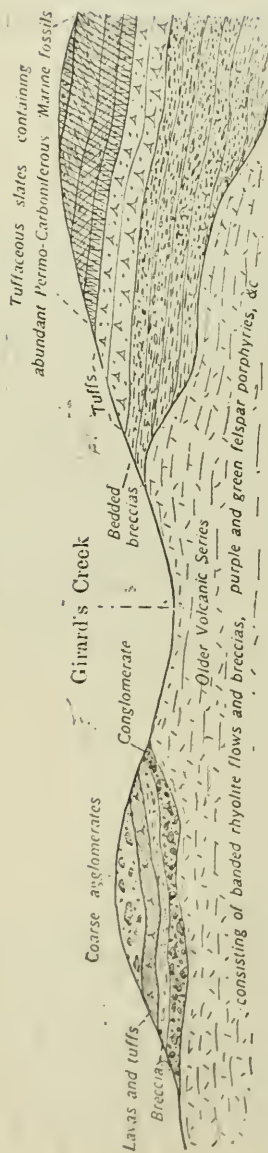
Thus a tangential thrust from the east was suggested, unless the Drake rocks proper should be decidedly younger than the Pretty Gully series.

Shortly afterwards observations proved the Drake slates and tuffs to be younger than the associated volcanics. The latter are referable to two distinct periods—an older consisting mainly of rhyolites, and a younger mainly of andesites.

\* These Boorook rhyolites were first shown to the Author in 1902, by Mr. Edgar Hall. During this visit the Author discovered the relations in time of the felsites and slates.

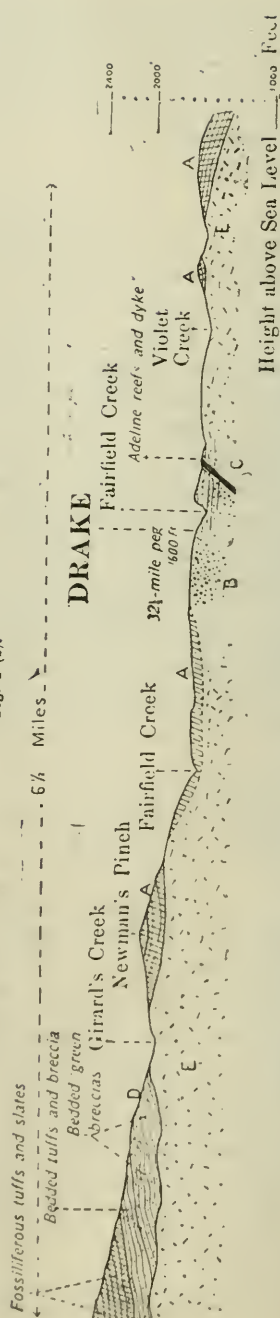
† Carboniferous type.

Fig. 1 (a).



Sketch section across country in vicinity of White Rock (outside of mapped area), illustrating relation of older and newer volcanics.

Fig. 1 (b).



Sketch section along Drake-road, showing relation between the older and newer volcanics.

- A, Stratified tuffs and breccias with associated agglomerates and lava flows.
- B, Older rhyolitic rocks.
- C, Older rhyolite breccias, apparently horizontal.
- D, Bedded breccias passing upwards into fossiliferous tuffs and slates.
- E, Older purple and green porphyry flows, breccias, and agglomerates.

Thus the whole, felsites and slates, were shown to belong to the one great period of sedimentation.\*

In June, 1903, when visiting Malarra, a coarse sphene-hornblendic granite, containing magnificent pink felspar crystals, was observed intruding the Drake felsites and bedded tuffs. Near Malarra and Timbarra this granite is in turn intruded by coarse acid granites, similar to the massif of Rivertree and Undercliff.

This rock† has a great development near Bolivia, Tenterfield, the 15-mile peg along the Tenterfield-Drake road, Wilson's Downfall, and Wallangarra, and in those localities has been intruded by the various typical fine and coarse sandy granites of New England. Moreover, this sphene-bearing granite has cut through the "blue granite" of Tenterfield, Wallangarra, and Black Swamp, while the latter in turn has intruded the Tenterfield and Deepwater felsites.

The great granite massifs had now been correlated, both with the Permo-Carboniferous strata and with each other. Some were ascertained to be valuable, and others valueless from a mining standpoint. Thus the "blue granite" and the remarkable sphene-hornblendic granite porphyry did not themselves contain metalliferous deposits of commercial value, but they had been intruded by numerous sandy granites, eurites, and pegmatites carrying tin,‡ also by still later diorite and allied dykes associated with gold, silver, lead, copper, and zinc veins.§

The fertile "blue granite" (dacite) of Tenterfield, Wellington Vale, Deepwater, and Tent Hill, which now, by reason of its relative weakness to erosive forces, occupies the valleys between the hills of younger but more resistant tin granites, was possibly of the nature of a large laccolith—that is, it had probably forced its way through and among the felsites, altered andesites, and other rock types forming northern and central New England.

The numerous high steep spurs radiating out from the head of Girard's Creek were capped with slates, while felsites were invariably met with on tracing the rocks either down the points of the spurs or along the channels of the ravine watercourses. In all a decided thickening of slates was observed to the west and north. The great scouring action of the Cataract River and its tributaries reveals this feature well.

The accompanying sketch sections illustrate the relations of the main felsite and slate masses.

Among the purple and green tuff, breccias, agglomerates, and lavas immediately behind the old "Fairfield Hotel," Permo-Carboniferous fossils were found, similar in all respects to those of the slates. Still later, when examining the rocks in Bullock Creek, similar beds of fossils were observed sandwiched in with layers of lava, tuffs, and felsite conglomerates.

\* The felsites themselves will be discussed later in a separate chapter.

† The writer would call attention to the economic importance of this truly magnificent rock. At Malarra and Undercliff (also to a slighter extent at the 15-mile peg on Tenterfield-Drake road) the rock is, perhaps, unexcelled for beauty by any granite known. The contrast of the great pink felspars with the dark setting of hornblende and mica is remarkable. The joints are wide apart and rectangularly arranged.

‡ E. C. Andrews. *Geology of New England*. Records Geol. Survey N. S. Wales, Vol. VIII, Pt. II, pp. 150, 151.

§ To these typical acid plutonies of New England the writer proposes the name "tin-granites," from their abundant tin (also bismuth, wolfram, molybdenite, scheelite, and monazite) contents.

In November, 1905, the following Permo-Carboniferous fossils were obtained from highly folded rocks along the Clarence River, a few miles below River-tree:—

*Productus subquadratus*, Morris. (Similar to form occurring at Mount Britton, Queensland.)

*Eurydesma cordata*, Morris.

*Deltopecten sub-quinquelineatus*, McCoy.

These indicate a Lower Marine age for the beds.

In 1907 the following forms were obtained by Mr. J. E. Carne, Assistant Government Geologist, in the railway cuttings some 6 or 7 miles west of Warwick:—

*Productus brachythærus*, G. B. Sby.

*Spirifera Stokesi* (?), König.

*Martiniopsis subradiata*, var. *Morrissi*, Eth. fil.

Crinoid stem.

These are Permo-Carboniferous, probably of Lower Marine age. On the Queensland geological map, they are marked as Gympie. The rocks in which these types occur are indurated clays and shales, interbedded with limestones, andesitic and felsitic tuffs and breccias and thin flaking shales covered with worm burrows. The whole series is excessively folded and faulted, and penetrated by the "tin granite." (See plate of sections showing rock structures found in Warwick Railway Cuttings, and Appendix B.)

From Permo-Carboniferous shales and sandstones of gentle dip at Kendall, Mr. J. E. Carne\* has obtained *Fenestella fossula* and *Strophalosia*; also *Eurydesma cordata* and *Aviculopecten Mitchelli* from Wauchope. Mr. Carne calls attention to the fact that at Kendall these beds are almost horizontal in disposition, while a little farther west, in approaching the New England Ranges, rocks of similar age are well folded.

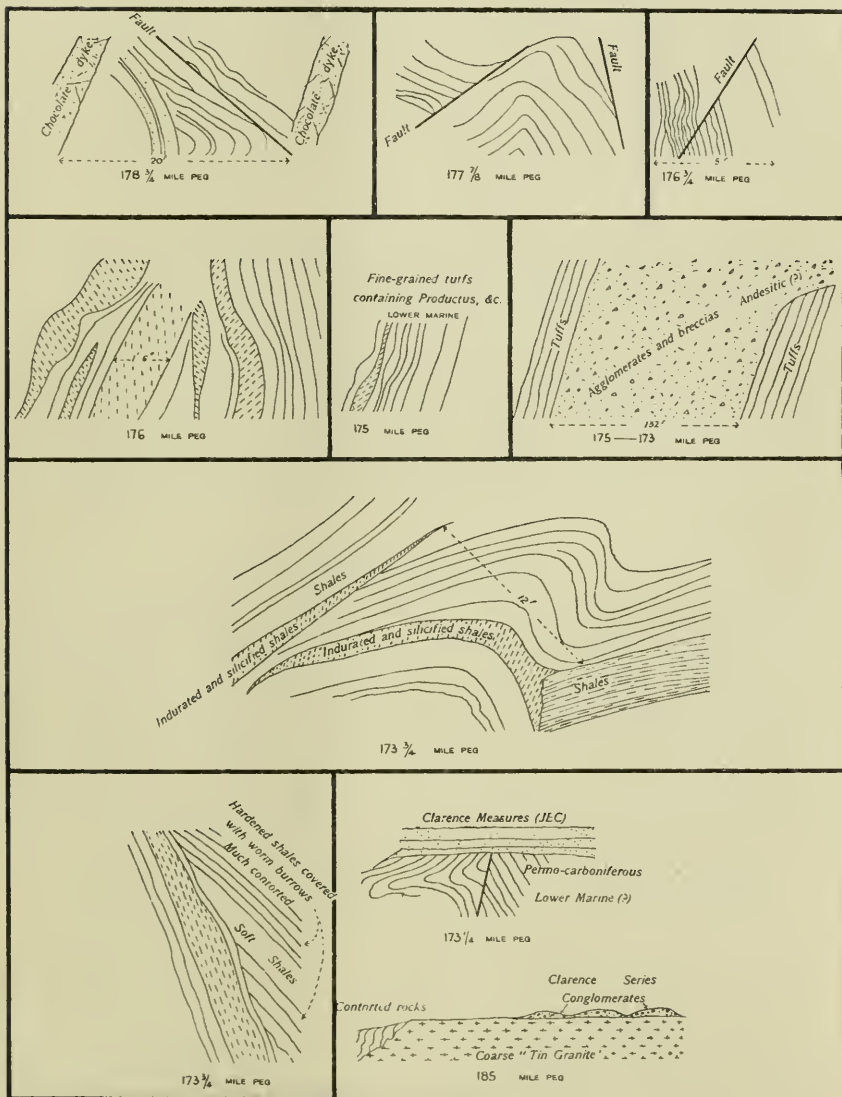
Again, in 1888, from Joagla Falls, about 20 miles east of Hillgrove, Mr. W. Anderson† obtained *Aviculopecten illawarrensis*, *Spirifera tasmaniensis*, and some traces of *Fenestella* in a limestone boulder.

If, now, the Permo-Carboniferous (Lower (?) Marine) strata, lying between Lionsville and Warwick—a distance of 100 miles—be followed eastward they will be found to pass unconformably beneath the Clarence Series. Having crossed the latter, one discovers a long north and south coastal strip of rocks unconformably overlain by the beds of the Clarence Basin. Their age is, undoubtedly, Palæozoic. They are intensely folded and faulted, and they are quite schistose in many places. No fossils have been found therein, although various observers have made careful search for same at several points between Brisbane and Coff's Harbour, a distance of 200 miles. They are separated from the more western Permo-Carboniferous series by the horizontally-bedded Clarence sandstones and Tertiary volcanics. A traverse across the continuously exposed Palæozoic strata to the south of the Clarence Series might result in the discovery of an unconformity between the two rock types thus exposed east and west of the Clarence Series. Until such work is done, or until such time as determinative fossils shall have been found in the highly contorted rocks of this coastal strip, the relations of the two Palæozoic masses will remain unsettled. On the one hand the eastern strip may represent

\* J. E. Carne. *Memoirs Geol. Survey No. 6: Lithgow or Western Coal-field*, 1907, p. 34.

† Ann. Rept. Dept. Mines N. S. Wales for 1888, p. 190.

Sections in railway cuttings near Warwick, Queensland  
 Shewing contorted Lower Marine (?) rocks





Gympie strata forming an eastern boundary to the Permo-Carboniferous sea, or again the two series may represent different conditions of deposition during the same great period of sedimentation.

This fact, however, one may be certain of, namely, that whereas, until quite recently, the Permo-Carboniferous as a factor in the building of New England was considered quite negligible, it has now been shown to be all important. Especially is this seen to be the case when one appreciates the area gained to New England by post Lower Marine and pre-Mesozoic granites. Doubtless more than 50 per cent. of the Palæozoic rocks of New England and associated eastern areas are referable to the momentous Permo-Carboniferous period.

Three interesting problems are thus suggested:—

- (1) What is the geographical significance of the undisturbed Permo-Carboniferous south of Sydney, the very gently tilted Maitland strata, and the strongly folded rocks of similar age several hundred miles only farther north, the latter also being extensively intruded by granites of varying age?
- (2) What is the relation of the Gympie beds of the Queensland geologists to the northern New South Wales Lower Marine beds?
- (3) What, also, is the relation between the coastal Palæozoic beds between Brisbane and Coff's Harbour, and the Permo-Carboniferous separated therefrom by the Clarence Basin sandstones?

### The Drake Volcanics.

The lavas of the Drake district present a difficult problem as regards a detailed sequence of events. They are studies in minutiae. Frequently, within the limits of a 10 or 20 acre block, as many as a dozen rock sub-types may be found. No dips are apparent except in certain of the latest inter-bedded breccia and conglomerate beds. Some of these, moreover, are dips only in the sense that loads of rubbish flung indiscriminately over each other may be said to possess dips.

The rocks of the area are of felsitic and andesitic types. Two periods of volcanic energy are indicated:—

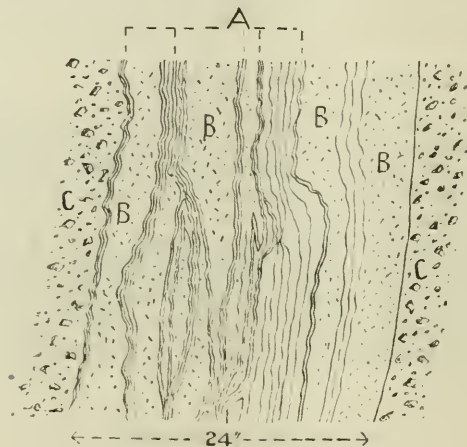
- (a) One productive of whitish to grey felsites, purple and green lavas, tuffs and breccias, and practically devoid of stratification planes.
- (b) A younger one, productive of blue and purple agglomerates, breccias, lavas, and tuffs deposited on a sinking sea-floor.

White Rock Gully was the first locality visited in this connection, and hence, as a centre, the sequence of the main volcanic events was made out. The gully is of the long, narrow, steep-sided variety, with an approximately cup-shaped head. At the base of the amphitheatre lies a mass of whitish-grey banded rhyolite breccia, traversed by a network of quartz veins. The grey breccia has been exposed by the removal of a slate and purple breccia cap during the development of the gully by the stream now draining it. It covers some 12 acres of ground. (See 3 on General Map.) The quartz composing the banded veins is mostly of the colloid variety. The upper sides of the gorge head are composed of *bedded* purple and green fossiliferous tuffs, associated with similarly coloured breccias and agglomerates. A mass of

columnar felsite and greenish-grey agglomerate forms the highest point of the gorge head. As mentioned previously, a great folded mass of slates and fossiliferous slaty tuffs had formerly stretched across this site.

In this rhyolite breccia patch (*vide* Main Map) numerous large and small bombs of banded rhyolite may be seen. In diameter some are as much as 5 feet. A fine felsitic tuff or lava itself composes the matrix. The accompanying diagrams illustrate this feature.

Fig. 2 (a).



Sketch sections of White Rock Reefs.

- A, Dark bluish chalcedonic quartz, containing sulphides of silver, lead, and zinc.
- B, Whitish quartz.
- C, Brecciated felsite matrix.

Fig. 2 (b).



Portion of one of the numerous agatiform quartz-veins between White Rock open cut and battery.

All the quartz-veins in this block show beautiful banding.

The quartz veins traversing this breccia are very interesting. Many of them are combed and intersect each other. At times they exceed 2 feet in width (Fig. 2, a and b.)

On three sides of the rhyolite breccia, green and purple breccias and agglomerates occur. Their positions are indicated by (9) on the General Map. No hard and fast junction with the "White Rock" breccia was observed; no separation of the two by quartz-filled joints or ferrous material;

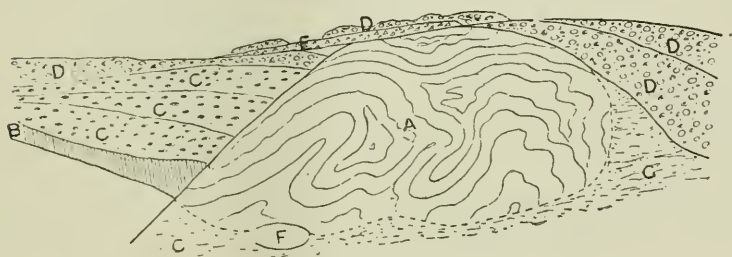
no dipping of the green and purple agglomerates towards the rhyolite mass. Colloid and agatiform quartz-veins cross both masses indifferently, but the main silver-veins appear to be confined to the rhyolite breccia. A couple of shallow shafts sunk in the associated green and purple breccias bottomed in the rhyolite breccia.

To the south and south-west these rhyolite masses are overlain by the stratified purple tuffs and breccias. Here also a fine greyish tuff occurs, apparently dipping at  $45^{\circ}$  easterly.

It was thought that the underground workings of the White Rock Mine might possibly reveal the connection between the rhyolite breccias and the associated green and purple rocks, but on examination they were found to be confined within the rhyolite mass.

About three-quarters of a mile farther down the valley a small dome of banded grey rhyolite lava outcrops near the stream-channel base. This rhyolite is rather similar in general appearance to the rock of which the "White Rock" breccia is composed. The occurrence, which is some 7 chains in diameter, outcrops on a steep sideling. (See [6] General Map.) Near the gorge base this rock is associated (the actual junction was not visible, owing to the thick cloak of waste and vegetation) with green and purple andesitic tuffs. It is, as shown in the accompanying section, buried under green breccias, green and purple agglomerates, and fossiliferous tuffs, which at times

Fig. 3.



Sketch section across banded grey to white felsite in White Rock Gully.

- A, Worn-down hill or remnant of old banded rhyolite floor.
- B, Green lava of later age.
- C, Purple tuffs and lapilli. These beds illustrate horizontal growth of talus after fashion of mullock tip formation.
- D, Purple and green tuffs, breccias, and agglomerates.
- E, Gently dipping tuff bed full of marine fossils.
- F, Remnant of purple porphyry.
- G, Waste sheet.

The waste sheet, as also the vegetation, prevents the correlation at this point of the banded rhyolite and the older green and purple porphyries.

show regular bedding, but oftentimes exhibit signs of overlapping such as may be seen in the arrangement of debris dumped over a tip-head, the loads being very variable in size. The whole of the base of White Rock Gorge, as also its middle slopes, is composed of various purple and green porphyries

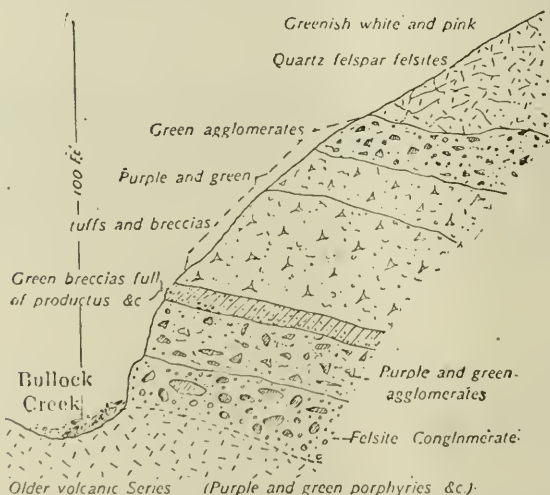
and breccias. Physiographically considered, they appear to be younger than the banded rhyolites and associated rhyolite breccias. All are undoubtedly covered by bedded fossiliferous tuffs and slates, also by purple and green andesitic breccias and agglomerates. The fossils are of marine types and belong to the Lower Marine division of the Permo-Carboniferous period.

In the case of the green tuffs and breccias, the later rocks possess dips at times well defined, the inclinations often determining the pitch of a hillside owing to the differential resistance to erosion exhibited by the beds. Especially well are the bedded newer varieties shown on both sides of the gorge, in the vicinity of the banded rhyolite inlier.

The breccias of Girard's Creek and cuttings may be mentioned in this connection. They belong to the newer series; they are distinctly bedded, and they post-date the newer agglomerate period. In hand specimens they appear as compact porphyries, their fragmentary nature being well exhibited only in field sections. By all gradations they pass upward into fossiliferous tuffs and slates.

One of the most instructive and interesting divisions of the later series (*i.e.*, the purple and green lavas, tuffs, breccias, and agglomerates) is that which comprises the conglomerate beds.

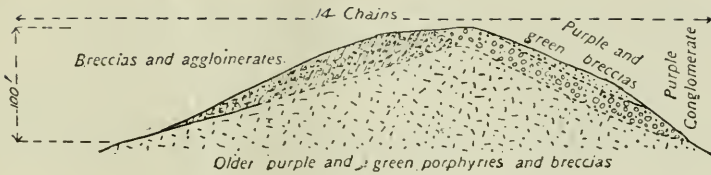
Fig. 4.



Section across older and newer rock series near corner of M.L's. 127, 108, 130, 135, in Bullock Creek.

In many cases a conglomerate bed will contain numerous angular and subangular volcanic blocks; or, again, a conglomerate mass will pass gradually into an agglomerate. Here, commingling of two processes is evidenced—in shallow water agglomerates have been primarily thrown out, where probably the sea reduced the mass to a conglomerate; oftentimes, however, the imposition of fresh agglomerate deluges checked the process of pebble formation. Redistribution with partial to complete rounding by waves of

Fig. 5.



Sketch section on County boundary near M.L. 98.

breccias and agglomerates intermittently discharged from volcanoes is most probably the origin of the great majority of such rock masses.

These were facts observed in one gorge. It appeared that there had been two periods of volcanicity—one probably terrestrial, the other and younger being submarine, but in shallow water. The older demonstration was productive mainly of rhyolites; the younger of andesitic breccias and agglomerates interbedded with marine fossiliferous strata. Agglomerates were common in the rocks of each age. Such coarse masses probably indicate the neighbourhood of centres of explosion, and it may well be that certain masses mark actual vent sites. The rapidly varying nature of the deposits without definite location of foci points rather to small discharges at various times from independent vents. The location of foci of eruption would necessarily be difficult owing to their *small* size, their partial covering by younger strata, and the dense mantle of vegetation.

The surrounding hills and ravines were examined next with a view to testing the accuracy of such assumption. For miles around the same order of events was observed. Masses of old and partially buried whitish, yellowish, and grey rhyolite breccias, agglomerates and lavas were found to abound. Sometimes they exhibited magnificent banding\*; at other times they were spherulitic, or studded with quartz and felspar crystals. In every case they occurred as inliers of the fossiliferous slate, tuff, and breccia series, while the similarity of certain of these inliers (as the felsite masses in Cedar-log Creek, Bullock Creek, Saw-pit Gully, and Mount Carrington) to the typical "White Rock" breccia is striking.

Two things were noted in connection with these older whitish grey felsites (and breccias):—

- (1) They were invariably overlain by purple and green agglomerates, breccias, lavas, and bedded tuffs.
- (2) They were almost uniformly associated with a network of veins containing colloid quartz, and carrying silver, gold, zinc, and galena ores.

In the Drake locality, Mount Carrington is the largest mass of these older exposed rocks. It is a remnant of a much dismantled† volcanic pile which had been covered by the younger lavas, breccias, and agglomerates, and revealed to-day only by the subsequent stripping of the overlying rocks by streams.

\* *E.g.*, the mass 1 mile south of the Adeline (No. 6 General Map), also the lavas forming the southwestern slopes of Mount Carrington.

† The dismantlement was the work, first'y, by waves, and, secondly, more recently by streams.

The side of the hill containing the reefs known as The Lone Hands, Parker and Hooten's, The Lady Duff, the majority of the Pioneers, and thence beyond G.L. 115, is composed of spherulitic and banded felsite.

The Carrington, Lady Mary, All Nations, Strauss', the Pig and Whistle, the Baalgammon, and Hot Scone Reefs are in hard felsite breccia, almost identical with that of White Rock, but possessing a finer texture. Other portions of the hill contain blue breccias and soft yellowish grey tuffs. At the Hampden and at Kelly's Silver Reefs (M.L. 41) the typical whitish-grey rhyolite breccia also occurs.

In the felsite breccias of the Hampden Mine colloid quartz networks were not observed. Here the original tuffaceous cementing to the breccia fragments appeared to be replaced by pyrites containing gold and silver values.

At Kelly's Silver-mine (M.L. 41) the typical grey breccia is present and traversed by a network of replacement quartz veins containing silver.

Similarly the green and purple felsite breccias of White Rock and Cedar-log Creeks are traversed by long bands of agatiform quartz. (Fig. 2, *a* and *b*).

Another interesting feature in connection with these older breccias and lavas is the great development therein of bands and masses of jasperoids in the form of bright red opaque ferruginous quartz.

They are common over the field, but are especially massive in the middle slopes of the south side of White Rock Gully, and also in Bullock and Cedar-log Creeks.

In the younger series of purple and green agglomerates, breccias, tuffs, and lavas there is apparently sign neither of these peculiar networks of colloid and agatiform quartz, nor of the masses of jasperoids characterising the older rocks.

These, however, as also the older rocks, are traversed by numerous gold and silver veins, *e.g.*, the Boorook and Lunatic Reefs, the veins in the slaty tuffs above White Rock, &c.

A huge dyke of basic composition crosses Mount Carrington. The dip is easterly at about 45°, and the width varies from 3 to 20 feet. With it are associated gold and copper-quartz reefs. A reef may accompany it along its foot or hanging wall, and then leaving it at a small angle gradually "pinch out." Other reefs maintain a rude parallelism with it, and then suffer gradual divergence therefrom with corresponding decrease in size.

The Carrington Reef, which occupies the footwall side of the dyke, is thought by many local miners to consist of a solid mass of quartz possessing defined walls. It, however, comprises a great number of small veins associated with one or two larger fairly defined channels, the country between which has been more or less completely replaced by silica. (Fig. 11, *a* and *b*.)

In other cases (The Lone Hands, &c.) the basic dyke appears from an examination of the stoped-out portions, to have cut across the reefs. This is borne out also by the testimony of the miners, *viz.*, that the reefs were "cut off" by the dyke in these places.

It is probable that the last-mentioned reefs belong to the earlier system of ore deposits.

A dyke of andesitic origin occurs in the older felsites at the Adeline Mine. It is beautifully porphyritic with large feldspars, and attains a maximum width of some 25 feet. The dip is westerly at about 45°.

The main Adeline Reef hugs the footwall of the dyke, although at times it is separated therefrom by strips of country rock. Several reefs of varying widths occur in its immediate vicinity on the hanging wall side. They are set closely together and curve sympathetically with the associated inclined wall of igneous rock.

In the case of this reef also it will be seen on examination that, very frequently, the quartz and ore masses are simply "replacements" of country.

#### *Deductions.*

As a result of the foregoing observations the following inferences appear to be justified:—

(a) The older felsite breccias and agglomerates may mark—

- (1) The actual sites of small vents; or
- (2) Masses thrown out of various neighbouring small vents.

Certainly, in one or two instances, as at the Hampden Mine, in Sawpit Gully, the rhyolite breccias are crudely bedded and alternate rapidly with differing rock types.

It is extremely probable however, that some of these breccias mark actual vent sites, while others represent ejectamenta situate some slight distance from the discharging vent.

(b) The younger green and purple andesitic agglomerates, so well shown on the south and east slopes of Mount Carrington, at Newman's Pinch, and on the White Rock Gorge slopes, occupy a very limited area, and appear to be arranged round a centre situate some half-a-mile south-east of the White Rock Mine.

(c) Two periods of ore deposition appear to be evidenced for the Drake district—

- (1) One contemporaneous with, and originating in, the decadence of the older volcanism.
- (2) One determined by the intrusion of the later slates and granites by basic dykes.

These periods of ore deposition need a slightly fuller description.

With the decrease in the older volcanic activity, a series of hot springs became the only expression of the dying fires beneath. Cracks innumerable appeared over the surface\* and along these water and steam, charged with gases, such as carbonic acid and sulphuretted hydrogen, were given off. These held various silver, lead, and zinc values in solution, which, as the steam and water arose, were, in part, deposited along the sides of the fissures.

At the same time, by similar agencies, the great masses of "jasperoids" were developed.

Denudation was then set up and the upper parts of the volcanic craters were removed. Then came subsidence, and the sea crept over the area. Simultaneously the slumbering fires were again set going; huge piles of agglomerates, breccias, and tuffs were spread over the shallow sea bottom. Sometimes the volcanic fires would slacken and the waves beat upon the agglomerates until they were partly converted into conglomerate beds, while in other places sea shells grew and multiplied. Craters have not been definitely

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\* The greater portion of the surface is still buried under the younger lavas and slates.

located. Apparently the centres of volcanic disturbance were small and closely set together, so that growing craters were continually tending to bury each other with volcanic débris.

These fires, in turn, became dormant; nevertheless subsidence of the sea-floor still progressed, the while the associated mountain ranges were suffering reduction.

At first the rapid streams swept masses of coarse fragments into the sea area. With continuous subsidence and slightly increasing distance from shore, great thicknesses of slates and fossiliferous tuffs succeeded to the bedded breccias.

Subsequently a force, coming apparently from the east, and acting as a vast slow shoving movement, approximately parallel to the earth's surface (as along the ground from Casino to Tenterfield), turned these flat-lying slates, tuffs, and breccias on edge, slightly only at Drake, but completely\* some miles eastwards. In this way another mountain range sprang into existence, and into the heart of the mass granites were thrust at several distinct times.

With the earlier plutonic visitations no mineral deposits of commercial value were associated, but from the youngest members (especially the very "sandy" examples) the tin, bismuth, wolfram, molybdenite and monazite deposits of New England were concentrated into valuable veins.

After these intrusions of granite a great host of diorite and allied dykes burst through the granites and slates of northern and central New England. Their intrusion was the signal for the uprising of heated waters containing gold, silver, lead, and copper ores. In this way the main reefs of Drake, Hillgrove, Rivertree, Howell, and other localities (*e.g.*, Swamp Oak) appear to have been formed.

It does not follow thus that one should expect each member of the New England reefs to be accompanied by a dyke, or that the ores must have been leached out of the same, but rather that these exposed dykes represent some of the highest points of tongues sent out along rock joints from a deeply-seated rock reservoir; that this same reservoir contained much water and acids; and that, subsequently to the dyke intrusions, the water was partly driven off from the cooling mass, and holding ores in solution derived partly from this rock mass, and in part from the older sediments through which they were circulating, had risen most frequently along the cracks determined or widened by the dyke intrusions, and along such planes of least resistance the ores had been deposited. The planes of the reefs frequently coincide with those of dykes, but may be at some little distance away.

Up and along these fissures, then, the heated waters circulated until the fissures were filled. The silica contained in the waters appears to have had a wonderful action on the "country," causing it to pass gradually into impure quartz. (Figs. 3 and 10.)

To the igneous rock types we have been here considering the Adeline and Carrington dykes evidently belong. The association of such dykes with reefs makes for geological permanency. Commercial permanency, however, depends on another set of conditions, to be discussed in a later chapter.

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\* To the north and north-east the rocks appear to have been highly contorted and faulted, yet containing fossils of Lower Marine types.

*Summary.*—The Drake Reefs were formed during two periods—

- (1) One, an older, during the hot-spring stage of the rhyolite displays. This was productive of silver-lead veins.
- (2) One during the basic-dyke stage, which concluded the granite intrusions. To this period belong the main gold and copper veins of northern New England. (The Howell silver-veins appear referable also to this period.)

As the streams laid low the mountains of the district, these reefs were exposed, and, in turn, gradually washed away. Thus the outcrops we see to-day on the Drake hillsides were, during periods preceding the present, doubtless thousands of feet below the old surface of the land.

The accompanying diagram illustrates roughly a probable mode of origin of these dykes and accompanying reefs.

Fig. 6.

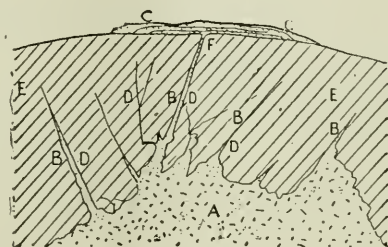


Diagram illustrating dyke intrusions from granite boss.

A is a mass of rock which has worked its way through the slates or felsites, EE. BBB are long tongues or dykes given off by A. Some of these never reached the surface. One, however, at F, has reached the surface and has overflowed, forming the lava sheet, CC.

DDD represent fissures formed alongside or *between* the dykes as a result of contraction of the country. These are filled with ores, segregated, for the greater part, by the hot water derived from the molten mass, A. As the land surface is worn down, these reefs are exposed.

#### *The influence of Topography on the Drake Reefs.*

We can here merely enumerate the main steps in the physiography of the Drake district.

1. The mountain ranges formed by the closing movements of the Permo-Carboniferous period were eroded, and the earlier Mesozoic sediments were laid down on their worn-down edges during a period of subsidence.
2. Several times during the Mesozoic period the land surface of New England appears to have been raised and worn down again almost to sea-level.
3. The Tertiary appears to have been ushered in by a decided uplift.
4. Valleys were formed in this surface.
5. Subsidence then ensued, and the river valleys were gradually filled with stream débris.
6. The gold and tin contents of the worn-down associated reefs were swept into these river beds and joggled gradually to the base of the river channels or on to hard layers forming false bottoms to the river drifts.

7. Cracks opened in the New England land surfaces and basalt floods welled thence over the district, burying these old river deposits. (Thus originated our "deep leads." *Example*.—Pretty Gully Lead.)

8. In this land mass a great plain was cut by streams at or near sea-level.

9. The land was lifted gradually, and this plain, now a plateau, was then, by streams, intersected with broad shallow valleys.

10. The country "was again hoisted," by jumps this time for some 3,000 feet.

11. This intermittent uplift gave the streams greater energy, and cutting deeply into the plateau they rapidly formed the magnificent gorges of the Clarence. The Cataract and Drake ravines fall into the latter category.

It is evident, then, that subsequently to the last great uplift the Drake reefs must have suffered heavily from erosion, for the town is now nearly 1,500 feet below the neighbouring plateau; whereas, but a short time ago, geologically speaking, the 3,000 feet-level extended in the vicinity of the Drake township.

As the reefs are gradually removed, portions of their metalliferous contents are washed into the neighbouring watercourses. Thus originate, as mentioned before, our alluvial gold and tin deposits.

Part, however,—and this is especially true for the copper contents of a lode—of the ore material is dissolved by the acids, both in the surface and ground waters. Should the reefs be well provided with joints, such as cross-courses, heads, and slides, the minerals so dissolved will be carried downwards along the reef planes, and, under favourable conditions, be redeposited at varying distances below the surface. The free oxygen in the surface water will tend to form carbonates and oxides in the upper portions, but as the surface water gets mixed up with the ground water, which contains but little free oxygen, the oxidised masses suffer marked decrease in volume, except for certain distances along cracks. The minerals in solution will now, along these cracks, be often reprecipitated as rich sulphurets. (Examples: Copper glance, copper pyrites, bornite.)

Similarly silver will be precipitated as silver glance, ruby silver, &c., while gold will be either thrown down in the free state or bound up in pyrites.

If then a reef be worn away very rapidly, and the ground be *abundantly and strongly* fissured, the copper, gold, and silver contents, when dissolved, may be expected to creep down these cracks and be reprecipitated as *shoots* *pockets*, or *bonanzas*, both above, and, for a certain distance, below water-level.\*

If, on the other hand, the wearing away be rapid and the reefs be not abundantly fissured, the mineral contents will, in great measure, be swept away, inasmuch as they have but little opportunity to creep downwards along the reef. In that case there would be but few *bonanzas*, but rather a general enrichment near the surface, and local enrichments at or near the intersections of reefs and the few crosscourses present.

Now, for New England generally, in late geological time (say the Pleistocene) there has been no widely-spread faulting or mountain making, whereby wholesale fracturing of reefs and country could be accomplished. Locally this applies also to Drake. Small fissures only occur, the country has been worn away very rapidly, and, save for a few minor movements, the district has been undisturbed during the gorge-cutting process.

\* For clear accounts of secondary enrichments of ore see—W. H. Wood, *Genesis of Ore Deposits*, pp. 473-497; S. F. Emmons, *ib.*, pp. 433-472 and references. C. Van Hise, *ib.*, pp. 282-432.

Ground water-level is also met with generally at slight depths only. Thus we should expect to get at Drake—

- (a) Fairly rich gold and silver outcrops.
- (b) Rich carbonates and oxides of copper near water-level and along the reef in the vicinity of certain cross or parallel joints.
- (c) Rich sulphides near and just below water-level, also along cross-courses below water-level; but the average tenor of the ore, away from these crosscourses, decreasing in value with increasing depth below ground water-level, until at depths of some several hundred feet we might expect to find the original unenriched deposits.

Drake has not been tested to any but slight depths, but so far as the field has been worked, this inference has been confirmed by experience, namely, that secondary enrichments, such as copper glance, bornite, cuprite, and native copper are not found in quantity at other than slight depths below water-level, except in the neighbourhood of crosscourses.

The Drake topography appears thus to have a pronounced influence on the richness of its ore deposits.

It will be interesting to compare the topography, climate, and ore deposits of western New South Wales with those of the eastern portion.

1. We have just seen how the decidedly eastern (coastal) portion of New South Wales is one of pronounced rainfall, recent considerable gentle uplift, and rapid plateau dissection.

2. The western area of the State is one of comparative aridity, of practically stable equilibrium, and has been so during recent geological time. While the New England and Monaro districts have been lifted and rapidly dissected by stream action, the Cobar and Broken Hill reef outcrops have been but little above sea-level; the main ore channels are large, and reef removal by streams is reduced almost to a minimum.

We would, therefore, in such a region, look for large masses of oxidised ore near the surface, and for considerable masses of rich sulphurets to be both associated with the oxidised portions and to occur below them. Heavy faultings in older times are not considered in this connection. The Broken Hill\* and Cobar ore occurrences appear to justify this conclusion.

#### *Summary of Drake Reefs.*

- 1. In point of numbers the reefs are important. They are, however, narrow in width.
- 2. Geologically considered, they may be considered fairly permanent.
- 3. Commercially they are dependent for success on a cheap metallurgical process, the *bulk* of the richer secondary ores having been already won.

#### DESCRIPTION OF REEFS.

The information supplied in the following pages concerning the Drake reefs is very imperfect, because the greater number of the mines have been abandoned for years and the shafts are almost full of water.

1. *White Rock*.—The ore deposits known as the “White Rock” consists of networks of agatiform colloid quartz veins traversing a small mass of

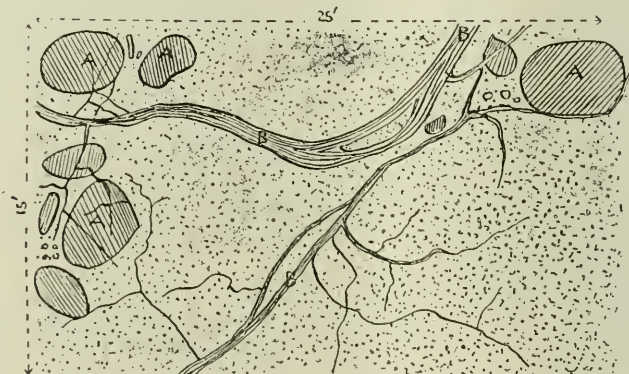
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\* J. B. Jaquet, *Geology of the Broken Hill Lode*: Mem. Geol. Survey N. S. Wales, 1894.

rhyolite breccia and associated purple, green, and grey tuffs, breccias, and agglomerates. They are confined to the older volcanics only, and appear to be referable to a decadent phase of volcanic action prior to the later period of volcanism. The "White Rock" breccia, in which these quartz networks are characteristically developed, occupies the base of a gorge, and is approximately elliptical in shape. The mass is, for the most part, composed of fine angular fragments of banded rhyolite, but in one spot a great development of roughly spheroidal bombs occur.

Fig. 7 (a) illustrates the occurrence of these bombs in one portion, and Fig. 7 (b) illustrates their distribution in another portion of the mass.

Fig. 7 (a).

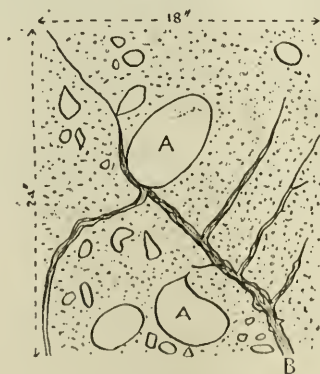


Illustrating occurrence of volcanic bombs and colloid quartz-veins at White Rock.

A, Felsite bombs.

B, Colloid quartz veinlets. The country is of felsite, breccia, and tuffs.

Fig. 7 (b).



White Rock bombs and quartz-vein networks.

A, Volcanic bombs (banded rhyolite).

B, Colloid quartz veins, banded, and containing silver, lead, and zinc. The country is a fine-grained rhyolite, breccia, and tuff.

Both the figures illustrate the association of bombs, breccias, and colloid quartz-vein networks.

The mass varies much in texture from point to point.

Partly encircling it is a mass of coarse and fine tuffs, breccias, and agglomerates of different character to the "White Rock" breccia. These merge gradually into, and are in places overlain by, purple and green porphyries. Above all, and occupying the higher points of the enclosing amphitheatrical valley, comes a mass of conglomerates and interstratified tuffs, breccias, and lavas. Lenticular patches of younger agglomerates also occur.

The amphitheatre is the work of a small stream during and post-dating the last great intermittent uplift, which formed the present plateau of New England. With the removal of the upper stratified series the "White Rock" breccia and associated rock masses were exposed. The rhyolite breccia, offering great relative resistance to stream action survives as a dome in the gully base.

Mr. E. F. Pittman has explained the "White Rock" breccia as a volcanic neck, and the networks of quartz-veins therein, containing silver, lead, and zinc values, as a result of later action in the "neck." The disposition of the large bombs apparently supports this view.

A comparison with similar neighbouring occurrences may be of interest—

1. In the same gully, and some 70 chains distant, a banded rhyolite flow occurs as an inlier, almost buried under later agglomerates, tuffs, breccias, and lavas. Its superior resistance to stream action is shown by its contour.

2. Under the fossiliferous marine slates and tuffs,  $1\frac{1}{2}$  mile south in Cedar-log Creek, patches of rhyolite, breccias, and lavas almost identical with "White Rock" breccia occur.

3. In Lower Cedar-log Creek, some 2 miles south-east of White Rock Mine, a dome of rhyolite, breccias, tuffs, and lavas occurs, associated with old purple and green porphyries. Through all these rocks a great network of colloid quartz-veins runs, as also the "jasperoids" mentioned in the earlier pages of the report.

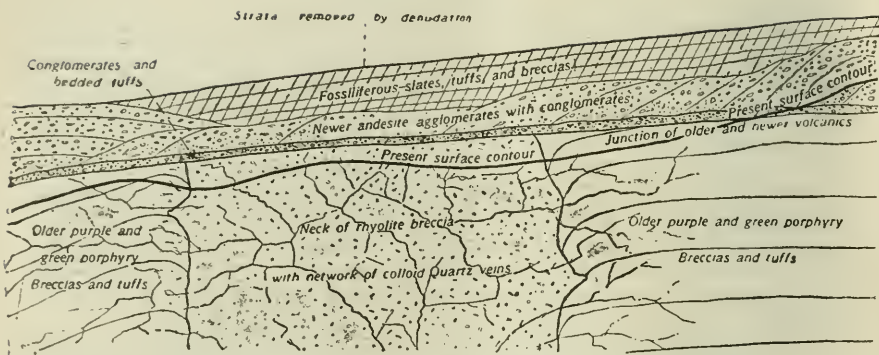
4. Almost identical conditions obtain some half mile north of the example cited in the previous paragraph.

5. A mass of rocks, embracing some 100 acres in area, occupies the township of Drake south of the main road. These are of various felsites, but the characteristic rock-types is a rhyolite breccia presenting great affinities with the "White Rock" breccia. At the Adeline Mine this breccia appears to form a *shallow horizontal bed* overlying green and bluish-grey felsite, tuffs, and breccias with bombs.

6. At M.L. 41, some  $3\frac{1}{4}$  miles north-east by east of White Rock, a rhyolite breccia occurs, associated with yellowish and greenish-yellow tuffs of the older volcanism. The mass is crossed with a network of colloid quartz-veins carrying silver sulphides. The resemblance to the White Rock occurrence is striking.

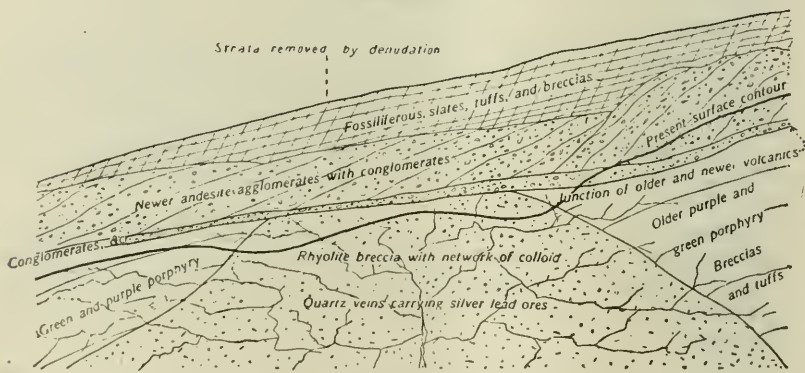
7. Mount Carrington, from 2 to 3 miles north-east of White Rock, consists of layers of rhyolite breccia, banded lava, green and yellow tuffs. These are all overlain by the later volcanics. The rock-types are strikingly similar to those of White Rock. A similar wealth of quartz-veins network also occurs at this spot.

Fig. 8 (a).  
IDEAL SECTIONS.



One explanation of the White Rock occurrence.

Fig. 8 (b).



Another explanation of the White Rock occurrence.

Of course, in an area such as that under description, volcanic necks must be of more or less frequent occurrence; but in a mass of closely associated rhyolite, breccias, and agglomerates, with other and younger *coarser* agglomerates occupying almost the whole of the intervening spaces, it is difficult to locate foci of eruption. Especially is this so in an area of dense plant undergrowths, in an area also where great developments of newer rocks prevent direct correlation of two neighbouring patches of older volcanics; and where no lines of junction can be obtained between two varying types of rock.

Apparently all these rhyolite inliers showing great developments of colloid quartz-vein networks and alteration of country to "jasperoids" represent the stump of a felsite volcano, or a volcano on the shoulders of which a series of parasitic craters had been developed, or a series of independent volcanic piles. The development of colloid quartz-veins arose as a dying phase before denudation and the later submarine volcanism.\*

\* One centre for the later agglomerates (as seen at Newman's Pinch, Mount Carrington, Bullock Creek, and White Rock Gully) appears to have been near the old "Fairfield Hotel."

The following notes on the White Rock property were supplied through the courtesy of Mr. L. Gundlach, manager of the Adeline and White Rock properties:—

A vertical shaft 180 feet deep was sunk in the breccia. Two drifts thence were run, one north and one south. The northern drive (110 feet) did not develop any ore body. The southern one (132 feet) showed ore near the shaft with a barren stretch of 25 feet. Thence a succession of veins of all sizes occurred, until at 130 feet the "galena" lode was struck. This was said to be approximately 10 feet in width and without gangue over a 60-foot long exposure. This averaged from 30 to 40 oz. silver. (L. Gundlach.) The 60-foot exposure does not represent the whole length of the "galena" lode, but merely that portion of it developed in prospecting operations south.

Veins were struck all the way down the shaft. One very steeply-dipping example, about a foot in width, remains in the shaft face about 70 or 80 feet down and carries gold values.\*

Originally the property was floated for £1,000,000 (?). A costly plant was erected. This scheme naturally soon collapsed.

Ten years later Mr. John Howell floated the property for £175,000. Dams were constructed, roads cut into the jungle, and a mining plant erected at a cost of from £36,000 to £40,000.

This venture soon failed, and the property was handed over to the Smelting Company of Australia (Dapto). The latter company lost control at a later date owing to non-fulfillment of labour conditions.

The original company erected a 60-head battery and a set of Frue vanners. Fine crushing was adopted, and the principal ore values thus passed into the slimes and were not recovered by the Frues. No provision was made for slime treatment.†

The second company did not adopt fine crushing. The ore was crushed to six holes per linear inch, and concentrated on jigs. The tailings are said to be nearly as rich as the concentrates, assaying something like 12 oz. silver per ton.

The following experiments were carried out on the tailings by Mr. Gundlach:—

- (1) They were crushed through a 30-mesh (linear) sieve in such a way as to produce very little slime; the resulting pulp was very carefully panned.

The concentrates yielded on assay some 23 oz. silver per ton, while the new tailings assayed 11 oz. per ton.

- (2) The ore was ground through a 30-mesh sieve and treated twice with oil. The first concentration assayed 81 oz. silver per ton. The second concentration assayed 16 oz. silver per ton. The tailings assayed 7 oz. silver per ton.
- (3) The same ore was crushed and passed through a 60 (linear) mesh sieve; oil concentration was adopted. The first concentration assayed 60 oz. silver per ton; the second concentration assayed 9 oz. silver per ton; tailings assayed 3.5 oz. silver per ton.

This represents approximately a 75 per cent. recovery, and suggests necessity of extraction by sliming.

\* A sample sent from this vein by Mr. J. P. Curran to the Mines Department yielded an assay value of 13 dwt. gold to the ton.

† The silver sulphides are very soft and the rhyolite country very hard.

The following is an account of a treatment of the White Rock ore by water concentration :—\*

REPORT ON THE TREATMENT OF THE "WHITE ROCK" ORE BY THE LÜHRIG SYSTEM,  
FOR THE AGENT-GENERAL OF NEW SOUTH WALES.

The ore, which I was requested to have tested by the Lührig Concentrating System, on behalf of the Government of New South Wales, was stacked in the ore stores of the "washer" of the Gute Gottes Mine, at Scharfenberg, on the Elbe, near Meissen, Germany.

It was contained in 202 bags, marked W.R., in all about 10½ tons. In character it was a mixture of light grey and nearly white siliceous and felspathic rock, containing more or less fine-grained pyrites and galena; the lighter portions appeared to be almost barren of ore—so much so as to cause the skilled working ore-dressers of the place to consider that portion worthless, and to suggest hand-picking to sort out the mineralised pieces. The whole bulk of the stuff, without any picking, was sent to the machinery for treatment.

A few pieces, taken indiscriminately from the bags in London, before they were sent to Germany, gave by assay:—Lead, 1·37 per cent.; silver, 43 oz. 5 dwt.; gold, 2 dwt. to the ton.

A sample carefully taken at Scharfenberg from the whole bulk, gave by assay:—Lead, 1·50 per cent.; silver, 39 oz. 4 dwt.; gold, traces to the ton.

The plant at Scharfenberg, one of Lührig's most simple systems, was designed for and is treating a poor siliceous ore, containing fine-grained galena blende and pyrites. On this "washer" the White Rock ore was easily treated, and gave most excellent results.

The concentrates produced gave by assay:—

|                         | Lead. | Silver.          | Gold.                |
|-------------------------|-------|------------------|----------------------|
| Jigger concentrates...  | 57 %  | 0·74 % = 241 oz. | 0·0002 % to the ton. |
| Vanner        "     ... | 55 %  | 0·73 % = 238 oz. | 0·00025 %   "   "    |

The assays were made by the Government officials at Freiberg. The results from the final tailings showed only traces of metals.

To obtain these results the material was worked with a view to the avoidance of loss.

Herewith I attach a copy of Herr Lührig's report. It will seem that he bases his estimates on a plant capable of putting through 1,200 tons of ore in a day of three eight-hour shifts. He also provides for sending the concentrates to Europe. Not knowing any of the local circumstances, mining expenses are excluded from the account. He makes the following statement:—

"Seven and a half tons of ore similar to the sample will yield 1 ton of concentrates, containing 228 oz. of silver; the latter being the important metal of the ore, gold and lead contents are not taken into consideration.

"Although the London assay showed 2 dwt. to the ton, none of the Freiberg determinations gave anything more than traces."

It can be seen by comparison between the assay returns of the products and Herr Lührig's statement, that he has allowed the very large margin of about 22 per cent. for contingencies, his reasons being:—When putting through large bodies of this class of ore, to make a comparatively high loss is often the more profitable procedure, owing to the cost of working being thereby cheapened, and the amount of machinery considerably lessened. Also with similar ores he has found that variations of the mineral contents are often met with, and in making his statement he has allowed a heavy margin for contingencies.

The result of this practical test has satisfied me that the Lührig system of concentrating is admirably adapted for the treatment of these ores.

Mr. Florence O'Driscoll was present with me at Scharfenberg, jointly making other tests. He also observed the working of the White Rock ores, and fully concurs with me in my conclusions.

COSMO NEWBERRY.

Several veins, averaging 18 inches in width, traversing the open cut workings, are being worked at present by tributors. Almost the whole of the vein material is taken. The contained silver sulphides are very fine in character, and they are not particularly associated with baser sulphides.

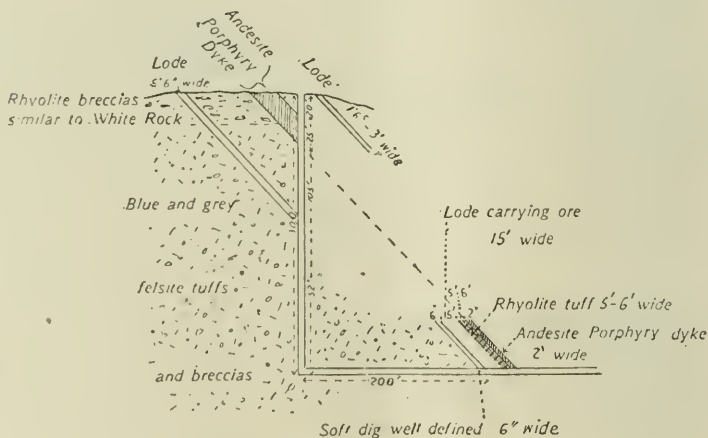


The accompanying plan (Fig. 10) shows the disposition of the workings. In the earlier exploitations shafts were sunk on the reefs to depths of about 100 feet, and a long low-level tunnel was driven on the main line of reef. The ores were copper and gold, and the gangue contained a considerable percentage of iron pyrites. A small reverberatory furnace was erected to treat the ore, fluxes being obtained from Black Creek, some 13 or 14 miles to the east.

At a much later period (1903) a shaft was sunk for 300 feet. [Fig. 10.]

Fig. 11 illustrates the testing of the reefs during this period. The reefs dip westerly, and the shaft was sunk vertically at a distance of about 150 feet from the outcrop. At a short distance from the surface the large andesite dyke was passed through (here some 20 feet thick). 150 feet from the surface the lode was cut 6 ft. 6 in. thick (B). At 300 feet down a crosscut was put into the west. At 200 feet a "dig" 6 inches in width was passed through, thence for 15 feet lode matter carrying ore (copper and gold); to this succeeded 5 or 6 feet of rhyolite tuff. Immediately on passing the tuff an andesitic dyke, strongly porphyritic with felspar crystals, was met. The dyke here had practically identical characters with the larger mass cut by the shaft at 150 feet. The idea entertained at the time was that this small dyke was merely a branch of the main andesite mass, and the crosscut was continued for a considerable distance with no results.

Fig. 10.



Sketch section across Adeline Reefs.

During my examination of Drake, the Adeline workings were filled with water, but the observations as shown in the section apparently evidence the local pinching of the dyke in the crosscut. Were a drift to be run along the lode formation both north and south, the dyke would most probably be found to gradually widen. Local contractions of dykes are not infrequent; as a matter of fact, the large dolerite (?) dyke of Mount Carrington pinches in width from some 20 to 3 feet in a distance of about 4 chains.

Previously to this exploitation, the management won over 600 tons of ore, averaging 3 oz. gold and 9 per cent. copper, and from 800 to 900 tons, averaging 13 dwt. gold, and from 4 to 5 per cent. copper.

Mr. L. Gundlach has cyanided over 4,000 tons of tailings for a recovery of 5 dwt. gold per ton. The difficulty of treatment consisted in eliminating the copper admixtures.

For treatment of the tailings, five 20-ton tailing vats and three solution vats were employed. The vats were filled by hand. No taps were used, short lengths of rubber being employed for directing into waste, overflow, or wash water, or into the solution pipe leading to the zinc box. The tailings were washed. The solutions varied from 20 to 40 per cent. in strength. Three solutions were used. Lime and caustic soda were also employed. The copper admixtures ranged from mere traces to 50 per cent. of the mass, chiefly as sulphate. The treatment lasted five days. The recovery was 70 per cent.

The slimes were also treated.

Between the years 1888 and 1904 the Adeline Mine yielded £31,037\* sterling in copper and gold values. At the present time the total value of the ore treated approximates to £40,000 sterling.

#### *The Carrington.*

This property occurs on a hill behind the township of Drake, about 550 feet in height. The eminence is composed of the older volcanics, and rhyolite breccias occupy that portion traversed by the Carrington outcrop. The breccia is very similar to that of the White Rock Mine.

A large dolerite (?) dyke, some 20 feet in width and dipping easterly at about 40°, appears to have been responsible, in part, for the formation of the Carrington and associated reefs.

The Carrington occurrence is rather a series of small quartz veins assuming parallelism of strike with the dyke for a certain distance, and gradually diverging therefrom to the south. An older network of quartz veinlets is apparently referable to the earlier volcanic period. Great silicification of the country traversed by the Carrington Reef and veinlets is noticeable, the original brecciated structure being plainly discernible in the silicified masses.

Fig. 12 (a) and (b) illustrates this silicification of the rhyolite breccia.

Diagrams illustrating method of occurrence of Carrington Lode.

Fig. 11 (a).

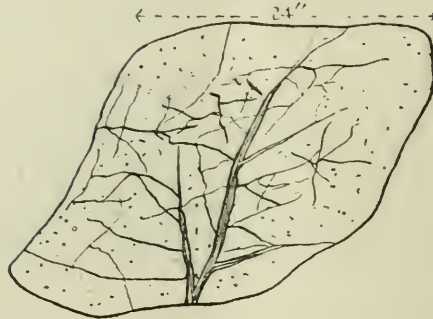


A, Mass of rhyolite breccia, altered in great measure to quartz by network of quartz veinlets.

B, Mass of rhyolite breccia, almost completely altered to quartz by the masses of quartz veinlets (C) traversing same.

\* For these and succeeding values of mine yields I am indebted to Mr. J. P. Curran, of Drake.  
13233—(b)

Fig. 11 (b).



Block of stone along Carrington outcrop, changed to quartz by the network of quartz veinlets traversing same.

The structure of the breccia can be distinctly seen.)

The Carrington Reef in the prospecting stage was worked for gold. An underlay shaft ( $40^\circ$ ) was sunk for 320 feet, and levels thence were run to secure the precious metal. The greater portion of the reef alongside the shaft has been stoped. The gold values were considerable in the cap, but suffered rapid decrease with depth. A vertical shaft was, at a later date, put down to the east. At 150 feet the dyke was passed through, and a drift of 26 feet thence to the west cut the main reef. The intervening country consisted of rhyolite breccias and tuffs, crossed with quartz veinlets from which as centres silicification was noticeable.

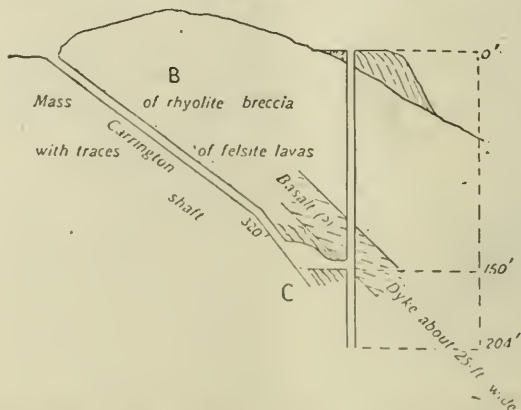
Fig. 12 (a) and (b) illustrate the relations of the reef, dyke, and shafts.

At the 300-foot level along the underlay shaft copper stains were observed in the reef. It is probable that from this point to water-level the copper values will decidedly improve.

The amount of gold won from this reef since 1888 is estimated at £5,555.

Diagrams illustrating occurrence of Carrington Reefs.

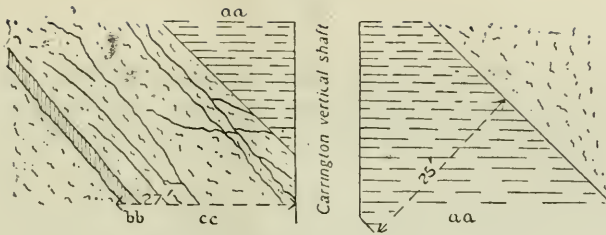
Fig. 12 (a).



(a) General relation of Carrington shafts, dyke, and reef.

B, Mass of rhyolite breccia 30 feet wide, underlying dyke and crossed with quartz-veins.

Fig. 12 (b).



(b) Enlargement of "B" in (a).

AA, Basic dyke some 25 feet wide.

BB, Quartz-vein, about 12 inches wide, carrying copper and gold.

CC, Mass of rhyolite breccia and lava turning into quartz by reason of numerous quartz-veins traversing it.

### *The Lady Jersey Mine.*

The property of this name lies some 6 miles south of Drake in Long Gully. The country consists of stratified tuffs, intruded by dark felspar porphyries. A large intrusive mass of sphene-hornblende granite lies some 700 or 800 yards to the south.

Although a locality from which £60,000 worth of gold has been obtained, the mine has been practically abandoned, and the workings are now almost filled with water. Above water-level the ore bodies have been stoped to the surface. Nowhere during my visit was there a sign of reef visible in the upper workings.

The reef evidently post-dates the granitic intrusions, and, therefore, belongs to the newer period of reef formation in northern New England.

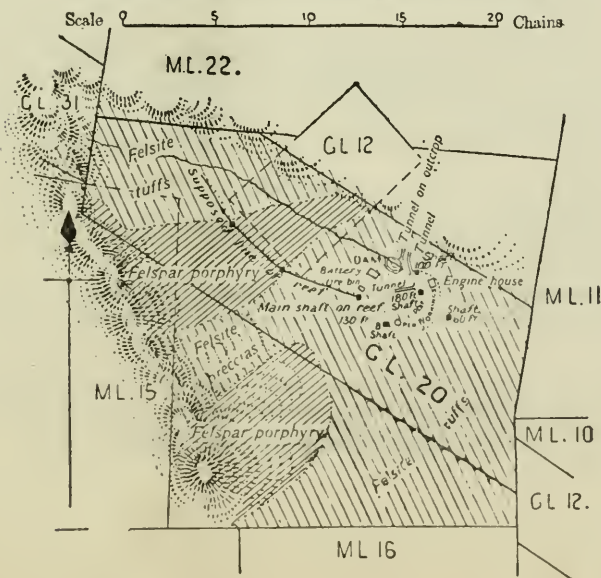
The appearance of the stopes are such as to strongly suggest the formation of a very narrow fissure, from which pronounced silicification and mineralisation of the "country" resulted in the form of large ore lenses.

The ore is gold, the gangue being mainly quartz with abundant zinc blende, and smaller amounts of copper and iron pyrites.

The accompanying plan (Fig. 13) illustrates the occurrence.

Fig. 13.

### Plan of the Lady Jersey workings at Long Gully



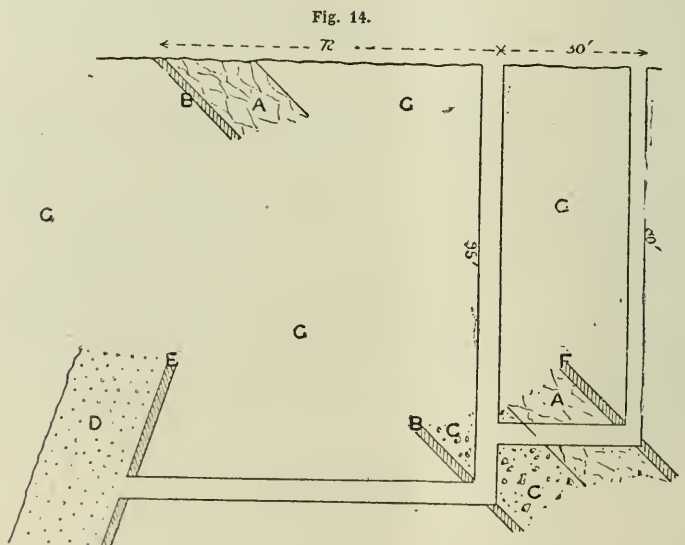
*The Lady Mary and Lady Mary Extended.*

The soft basic dyke and reefs of the blocks under consideration appear to be continuations of the Carrington line. The country is a rhyolite breccia of "White Rock" type.

Fig. 14 illustrates the relations of the various reefs, the dyke, and workings. A vertical shaft, 83 feet deep, proved the basic dyke. A crosscut, 23 feet in length, was put through the dyke, thence for 15 feet west. Silicification of country was noticeable, and a strong quartz reef was cut (The Carrington).

Another vertical shaft was sunk a little to the west, which cut the dyke at 70 feet, and the (Carrington) reef at 90 feet.

A drift was run thence 45 feet south, then 22 feet south-west, and continued about 60 feet west. This cut the Lady Mary Extended (The Red Reef) possessing a dip of  $60^\circ$  westerly.



Sketch section illustrating occurrence of Carrington and Lady Mary Reefs in McCrossan and Party's workings.

- A, Basic dyke, dipping east at  $45^\circ$ .
  - B, Carrington Reef.
  - C, Mass of felsite breccia underlying dyke, being converted into quartz by small quartz-veins.
  - D, Pipeclay formation 20 feet wide (crushed (?) felsite), carrying numerous veins of copper glance.
  - E, Vein of quartz carrying gold and copper (Lady Mary Reef).
  - F, Quartz reef 2, feet wide.
  - G, Felsite breccias.
- All these features have been treated as though in one plane.  
A shaft, 140 feet deep, has also been sunk, from which the ore at D and E is being won.

This shows a reverse of dip as compared with the Carrington (Fig. 12a).

The Lady Mary Extended forms a continuation of the Lady Mary Reef, and is a strong quartz reef containing gold and copper values.

At first glance an intersection with the Carrington Reef at a higher level is suggested, but the evidence of the present exploiting party (Messrs. McCrossan) suggests the occurrence of a fault which has cut the reef off at a higher level. The stopes being mullocked up, I was unable to ascertain the accuracy of this statement.

Immediately above this reef is a clay formation (with slight traces only of quartz) containing numerous impregnations and veinlets of copper-glance with rarer nodules of copper carbonates.

A vertical shaft was sunk 147 feet to win this ore body. One of the chambers excavated in the clay formation, which is either a decomposed dyke or an altered rhyolite breccia, exceeded 22 feet in width, and from it, according to Mr. J. Lukey, of Drake, £3,000 worth of copper, exclusive of smelting charges, was won. By concentration at Sawpit Gully also with batteries, Wilfley tables, and Frue vanners, £700 worth of copper, and £800 of gold were obtained.\*

The clay formation was extracted for some 30 feet below the new shaft. Here copper glance values were still obtained, and there was no sign of water-level. There is no reason to doubt the continued existence of these rich copper contents to water-level, and to some little distance below that level. Below that the glance will doubtless give place to much leaner pyrites.

#### *The Pioneer workings.*

The Pioneer Reef is strongly marked, and runs clear across Mount Carrington. Its dip is about 45° westerly, and it has been worked by three underlay shafts. No. 1 shaft is about 200 feet, No. 2, is 80 feet, and No. 3, 180 feet in depth. All three shafts are connected, and considerable stoping of the reef has been effected. Recently a winding tunnel has been driven in what, most probably, is the lower development of the Pioneer. In total length the drift is about 1,000 feet, and at a spot vertically beneath the hill crest traversed by the reef outcrop, is 300 feet below the surface. The width of the reef is variable, averaging from 1 to 2 feet. The ores are gold and copper; the gangue is quartz, with about 15 per cent. of pyrites. The country along the upper levels consists of greyish-blue rhyolite tuffs breccias and agglomerates, while along the lower levels it is of breccias and banded (?) rhyolites.

The position of this line of reef is indicated on the map of Mount Carrington. The value of the ore raised from the Pioneer Reef up till 1905 was about £7,000 sterling. Since that date the long low level tunnel has been driven on the reef revealing fair values of gold and copper.

#### *The Mascotte.*

A considerable amount of work has been carried on in this locality. (See Fig. 15, also General Map.) The ore mined for is silver and the country consists of rhyolite breccias of types similar to White Rock and Mount Carrington. Native silver and silver sulphides occur.

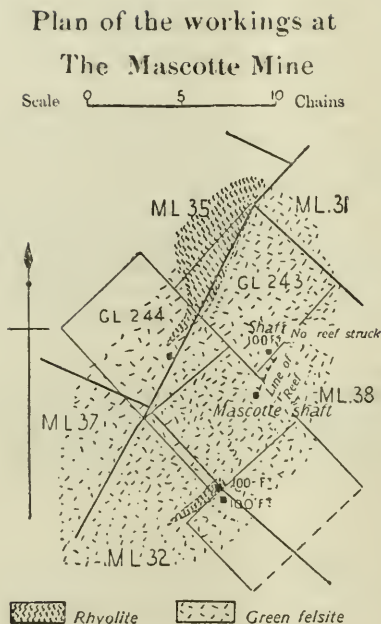
The mine has been practically abandoned for several years past. No opportunity offered for examination of the workings.

The amount of ore won between the years 1888 and 1904 was valued at £8,882.

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\* The yield of the Lady Mary was £0,264.

Fig. 5.



### *The Hampden.*

This mine occurs in Sawpit Gully, 1 mile north of Drake. The country consists of rhyolite breccias, grey and yellowish and bluish-grey in colour, and very similar to the rocks occurring at the Carrington and Lady Mary workings, about a mile distant. Several shafts, varying in depth from 100 to 200 feet, have been sunk and crosscuts have been run therefrom to exploit the ground. The breccias have a rude arrangement in layers. No decided vein appears to have been encountered, the ore occurring in a breccia, throughout which the original cementing material has been replaced by pyrites containing gold and silver values. The ore bodies, which appear to be of considerable size, are reported to be worth about 25s. per ton.

The ground being abandoned in 1904, no opportunity was offered of examining the ore masses *in situ*. The occurrence, however, is probably due to the gaseous and hydrothermal action of decadent volcanism on the rhyolite breccias.

A large and expensive plant was erected to treat the stone. The battery (20-head of stampers) was obtained from the White Rock plant. Frue vanners and Wilfley tables, as also a cyanide plant, were erected.

The amount of ore raised was valued at £3,473.

### *All Nations' Claim.*

This property occurs at the head of Sawpit Gully in rhyolite breccias and tuffs of the characteristic Mount Carrington types.

The ground was exploited by means of a shaft 150 (?) feet deep, also by cross-cuts and tunnels. The reef or reefs were not examined on account of the discontinuance of mining operations here for several years past.

The ore is gold, the gangue being a pyritous quartz.

A battery was erected to treat the ore.

The value of the ore raised since 1888 was £6,216.

#### *Strauss' Claim.*

These workings have been abandoned for some considerable time. They consist of an open cut, several shafts, and a tunnel driven in from Sawpit Gully. The open cut yields a section of bedded breccias and tuffs. A belt of conglomerate appears to have been traversed by a shaft sunk at the mouth of the tunnel. The value of the ore raised was £2,619.

#### *The Pig and Whistle.*

The reef of this name is a well-defined fissure vein near the Lady Mary property, traversing rhyolite breccias of the ordinary Mount Carrington types. The dip is easterly, having a value of  $70^\circ$  in the upper, and of  $50^\circ$  in the lower, portions of the reef. The depth attained was 130 feet on the underlay. Thence to the surface, alongside the reef, a considerable amount of stoping has been carried out. A drive 150 feet long was put below the 100 feet level.

The ores are gold and copper, and the gangue is quartz, containing about 15 per cent. of pyrites and zinc blende.

Upwards of 2 oz. gold per ton occurred along the upper levels, and about 1 oz. 15 dwt. per ton at the bottom. The copper amounted to about 4 per cent. as copper glance, cuprite, and native copper. At 100 feet a flat crosscourse was met. Intersecting both this and the reef is a small vertical crosscourse. Along this, and in its vicinity, the reef material consists of beautifully crystallised cuprite and native copper.

Water level was met with at about 70 feet below the surface.

The value of the ore raised between the dates 1888 and 1904 was £2,593.

#### *The Perseverance.*

This is a well-defined fissure vein, occurring in rhyolite breccias, near the summit of Mount Carrington. Several shafts were sunk to exploit the reef, the two most important being 90 and 76 feet deep. The dip is about  $50^\circ$  to the north-west. Fig. 14 illustrates the method of working the vein. The width varied from 2 to 4 feet. The gangue was white quartz with considerable percentages of iron pyrites and zinc blende.

The ores were gold and copper.

The value of the ore raised was £2,016.

#### *Parker's Claim.*

This property was exploited by means of two shafts and a connecting driver; the southern shaft is 96 feet and the northern one 140 feet in depth. The reef has a dip to the east, varying in amount from 60 to 70 degrees. It is well-defined and is from 1 to 2 feet in width. The ores are copper and gold; the gangue is quartz with considerable admixtures of iron sulphides.

The country consists of felsite breccias underlain by banded rhyolites.

From the upper portion of the reef the average yields were (from concentrated stone) 5 oz. gold per ton, and 14 per cent. copper. At 100 feet these

values had decreased considerably. A crosscourse from 2 to 3 feet in width influenced the reef materially to a distance of some 30 feet on each side. Away from this crosscourse the reef shows marked decrease in values.

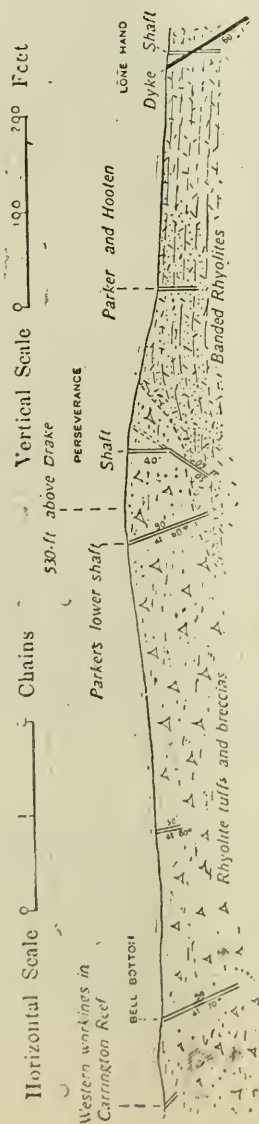
Ground water-level is some 50 feet below the surface, and mining operations were finally suspended owing to the water trouble.

Fig. 16 illustrates the relation of this reef with the Carrington and Perseverance lines.

All of them appear to have been determined, in great measure, by the large basic dyke traversing the hill.

Mr. Parker, the owner, is at present driving a low-level tunnel to prove the reef at a depth of 175 feet.

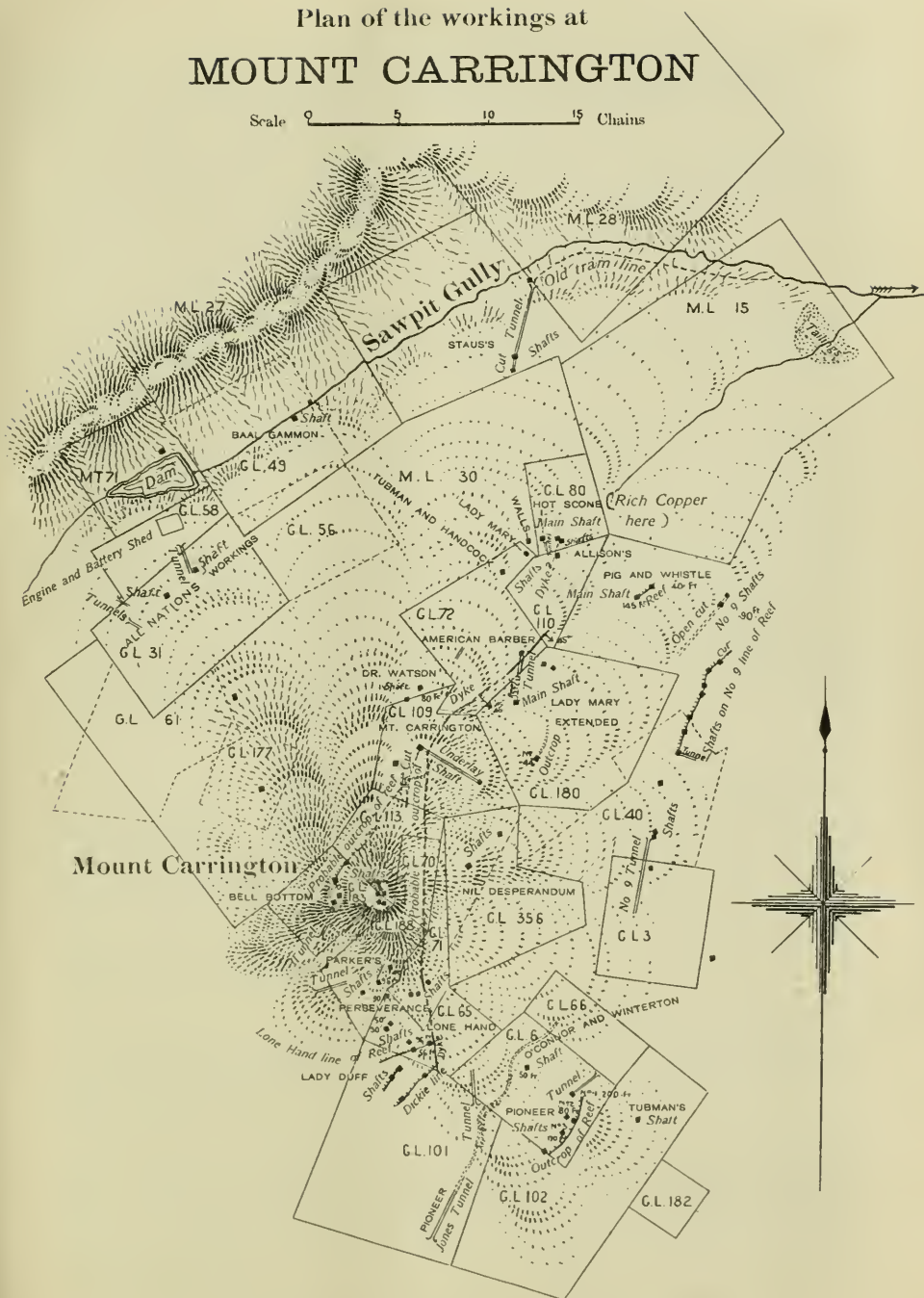
Fig. 16.



Section across Perseverance, Parker's, Bell Bottom, and Carrington lines of reef.

# Plan of the workings at MOUNT CARRINGTON

Scale 0 5 10 15 Chains





## No. 9.

This is a well-defined line of reef traversing Mount Carrington at a lower level than the Pioneer, Parker's, Perseverance, and Carrington Reefs. The country consists of greyish felsite breccias and tuffs lying just outside of the belt of characteristic Carrington rhyolite breccias.

Prospecting has been carried out by means of some nine or ten shafts, varying from 70 to 100 feet in width. The strike is north-north-west, and the dip westerly at an average amount of 60°.

The ore is copper, as amorphous glance and rich cupriferous pyrites.

The gangue appears to be a *highly* pyritic quartz.

From the very limited observations possible during my visit, the reef appears to be of considerable size and importance, and, excepting the important Adeline Reef, is probably one of the most promising lines should a smelting campaign be undertaken.

Parallel with this line, and at but a very short distance from it, another strongly marked reef occurs carrying copper and lead.

Heavy zinc admixtures, however, occur throughout the ore as carbonates and sulphides.

Attention may here be directed to the fact that a highly mineralised belt of country exists, both at the Lady Mary and Lady Mary Extended, and in the immediate surroundings to the north and north-west. The No. 9, the Pioneer, the Hot Scone, Parker's, and other reefs are here so closely associated,—they have produced so much ore, and withal do not appear to have been tested to any but insignificant depths, that another vigorous prospecting claim would be fully justified. A reverberatory furnace could be used in conjunction with such mining operations.

*Kelly's Block.*

This is the belt of rhyolite breccias (of types similar to characteristic White Rock and Mount Carrington breccias) covered by M.L. 41.

The ore bodies are contained in a network of colloid quartz-veins, which same do not, apparently, extend into the younger neighbouring volcanic series. The ores are native silver and silver sulphides.

The upper portions only of the mass have been worked, but these have yielded rich returns up to date.

*Other properties.*

(1) A number of other fairly well defined lines of reef occur on Mount Carrington.\* Prospecting operations have been conducted by means of shafts varying from 70 feet to 100 feet in depth, and by crosscuts put in at various levels.

Such are the Nil Desperandum, Baalgammon, Hot Scone, Lone Hand, Lady Duff, Tubman's, Parker and Horton's, (a gold-quartz-vein, half to three quarters of an inch in width, carrying from 17 oz. to 19 oz. of gold per ton; it appears to belong to the older volcanic period), and other lines.

The reefs belong to both periods of ore formation. Copper and gold are the ores mined for.

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\* The Lead Block is another line near Drake at which considerable work has been done.

(2) *Outside Drake proper.\**(a) *Boorook.*

The country consists of fossiliferous marine slates, tuffs, and older volcanics. The ores are silver-minerals. Exploitation was carried on by means of a shaft 320 feet deep. Oxidised ores were met with to a depth of 80 feet from the surface. Below that sulphides were encountered. At this juncture furnaces and other appliances for the proper extraction of the metal were erected by an experienced metallurgist, and successful extraction was accomplished for a considerable period.

At the 150 feet level a large bunch of sulphide ore was met with, some 19 feet wide in the widest portion, and averaging 40 oz. of silver per ton. At the 300 feet level a similar bunch was met with. When this pocket was worked out the mine was abandoned.

*Red Rock Mine.†*

The ore-bearing deposits at the locality of this name occur in volcanic breccias very similar to the older Drake types. The distance from the latter place is about 10 miles in a north-westerly direction. From the mine the country breaks precipitously to the Cataract River, some 750 feet below.

The gold-bearing lodes here are numerous, but the ore is low in value, 9 dwt. of gold to the ton being the highest known yield. In the Red Rock Company's mine a large deposit of zinc has been met with at the 100 feet level. The ore (zinc) is of a fair quality, and will concentrate up to 50 or 60 per cent. of metal.

*Lunatic Gold-field.*

This field has been abandoned for a considerable time. The country consists of fossiliferous slates and tuffs apparently of similar age to the Drake series proper. The reefs evidently belong to the younger system of the district.

The reefs exploited were numerous, and include the Lunatic, Golden Crown, Perseverance, Caledonian, Victoria, Little Victoria, and Martin's Reefs.

The following extract from a previous report‡ by this department, may be taken as a general description of the field:

*“Lunatic.”*

“Upon the southern end of the reef three shafts were sunk about twenty years ago. No bulk crushings were ever made of stone from these shafts, and they have long since fallen in.”

In No. 8 claim, about 4 chains north of the last-mentioned shafts, four shafts, each about 100 feet deep, have been sunk, and some driving has been carried out. One of the shafts would seem to be intact. I was informed by Mr. Curran, Mining Registrar, that a small quantity of rich stone was obtained here, and that heavy water was encountered. The claim has been abandoned for nearly twenty years.

Exhibition Claim (Phoenix) is situated immediately north of No. 8 claim. A shaft was sunk to a depth of 150 feet. . . . At intervals the reef has been proved by shallow shafts between the last-mentioned claim and the prospecting claim, which is situated upon the southern end of the reef.

\* For the following notes I am indebted to Mr. J. P. Curran, of Drake, the workings not being accessible.

† For other information see T. W. E. David, Ann. Rept., Dept. Mines for 1886, pp. 161, 162.

‡ J. B. Jaquet, Ann. Rept. Dept. Mines for 1896, pp. 126-128.

*Prospector's Claim.*

This is practically the only claim that was worked for any length of time. A main shaft, which is now intact, has been sunk to a depth of 203 feet, and five lesser shafts have been sunk to depths of from 50 to 80 feet. The claim was worked intermittently for seven years, and several hundred tons of ore raised from it. After it had been abandoned for some years it was again taken up by Ashbury and Party, who received Government aid to sink the shaft from 144 to 200 feet. No stoping was ever done by the party, and having exhausted their grant they abandoned the mine, and it has been idle ever since. The reef at the bottom of the shaft was, I am informed, only 3 inches thick.

*Conclusion.*

The reefs of Drake are very numerous, but possess neither great length nor width. The caps and upper portions in almost every example yield rich values of copper glance, copper pyrites, native silver, silver sulphides, and gold, but apparently decrease markedly in value with increase of depth. Small crosscourses apparently have been decidedly influential in enriching reefs.

The majority of the reefs possess a quartz gangue, containing from 10 to 15 per cent. pyrites. Exceptions are the Adeline and No. 9 lines, which contain considerably larger pyritic percentages. Zinc (as also lead) admixtures are common.

Recovery of gold from the ores by ordinary crushing methods has proved insufficient on this field. Various concentrating schemes for saving copper have been adopted, such as crushing and treatment on Wilfley tables and Frue vanners. In many cases these have also proved unsatisfactory, owing to the exceedingly fine state of division in which the rich sooty copper glance occurs.

When concentrated the ore is forwarded to various smelting companies for treatment. But seeing that a great portion of the rich oxidised and sulphuret masses have already been won, leaving the leaner and more complex pyritic ores, the expense of concentrating, with subsequent carriage to smelting works (about £2 per ton), has proved prohibitive to the great majority of the local miners.

Several attempts at local smelting (as the Adeline and White Rock ventures) have already been made, but without success.

It has been suggested that the erection of a smelter at Drake would cause a revival in mining, and several years since an application was made for a Government smelter. The application was refused.

Ore apparently does not here exist in quantity sufficient to warrant the erection of a water-jacket capable of dealing with from 10,000 to 20,000 tons a year. Ore, however, of fair quality, and sufficient for the continuous feeding of one, or probably two, reverberatories exists, but is scattered over the field in small lenticular reefs. These are held by lessees, whose name is almost legion. With the exception of the Adeline, No. 9, and a couple of smaller lines of reef, the ore is of a very siliceous type. Decided zinc admixtures occur in certain reefs. Fuel, as wood, exists in abundance on the spot, but fluxes, as iron oxides and limestone, would be necessary, and would have to be brought from Black Creek, some 13 miles distant.

It is very probable that were the Drake mines, or even any prominent group of Drake mines, under one ownership, a smelting campaign on a moderate

scale might be carried on successfully, since proper selection of ores could be made. Thus, such a group of mines as the northern extension of the Pioneer, the No. 9, The Lady Mary, The Lady Mary Extended, The Hot Scone, and associated reefs, if under one ownership, should be able to yield a supply of ore sufficient for the needs of a reverberatory furnace. The Adeline also would probably furnish enough ore itself to keep a small reverberatory going.

With regard, however, to the field generally, the multiple interests existent, and the futility of guarantee on the part of holders, whose only capital is their physical strength, must be overcome before a successful solution of the problem of ore treatment can be found.

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## APPENDIX A.

THE following extract from a report, dated 6th March, 1899, shows that Mr. J. A. Watt, formerly Geological Surveyor in this State, was aware of the relative ages of the volcanism generally, and the later sedimentation.

Mr. Watt's report was not seen until the present Drake report had been completed.

*Report by Mr J. A. Watt.*

"With the exception of Mount Carrington, which lies about half a mile to the north-east of the township, the rocks surrounding Drake consist of a bedded series of volcanic tuffs and agglomerates of a felsitic character, with, perhaps, occasional bands of felsite representing ancient lava flows of this rock. Sections of the beds of tuffs and agglomerate are well seen in the road-cutting between Newman's Pinch and the township.

"These beds become finer-grained as they are traced westward from Drake, and at about 4 miles to the west of the town the uppermost beds were found to be fossiliferous, containing casts of marine shells and corals in abundance.

"Mount Carrington, which stands at an elevation of about 500 feet above the town of Drake, seems to consist largely of solid felsitic material, which is intersected in all directions by veins of quartz, some of which are gold and copper bearing. Other parts of the mount consist of felsitic fragmentary material in which, in one place, viz., at the All Nation's Mine, rounded masses of felsite are found embedded in a ground mass of the same material.

"All the evidence would seem to point to Mount Carrington as having been one of the centres of eruption, from which the volcanic materials forming the surrounding beds of tuff and agglomerate were ejected. It would, therefore, represent the stump of an ancient volcano."

## APPENDIX B.

As shown in the sections facing p. 10, the Warwick series has been intensely folded and faulted. Some observers may find the origin of such intense action in the intrusion of the sediments by the "Tin-Granite." The granite, however, is distant some 10 or 12 miles, and can have had but little influence in mashing the Permo-Carboniferous strata.

It may again be thought that the Warwick crumpling has been more pronounced than that to which the neighbouring Drake sediments has been subjected, and that therefore the former are the older. It must be remembered, however, that the intense crumpling at Warwick has been revealed only by the railway cutting operations, and that in ordinary outcrops the Drake and Warwick areas appear very similar as regards the degree of folding attained by the sediments.

If, however, as the fossil evidence multiplies, it be still found that the Warwick and neighbouring areas are essentially of age not greater than Lower Marine, then we have to record the highly interesting fact that a "critical period," with all its wonderful accompaniment of repeated plutonic intrusions, occurred at the close of the Palæozoic for New England and still more northern areas, while unaffected Maitland and other neighbouring southern districts.

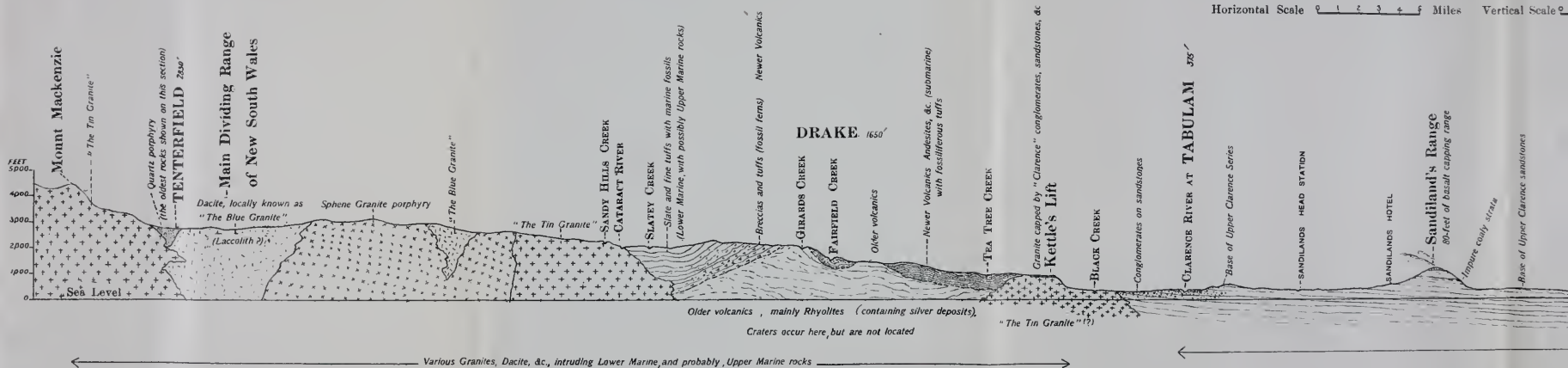
The fossils found up to the present certainly do not form as complete a set as might be wished, yet they point, undoubtedly, either to a Lower Marine age for the strata, or "a mingling of Lower Marine with slightly older types."—(W. S. Dun.)

Since that period, Eastern Australia appears to have gradually developed into a geographical unit, in which state it has remained during, practically, the whole of tertiary and Post-Tertiary time.



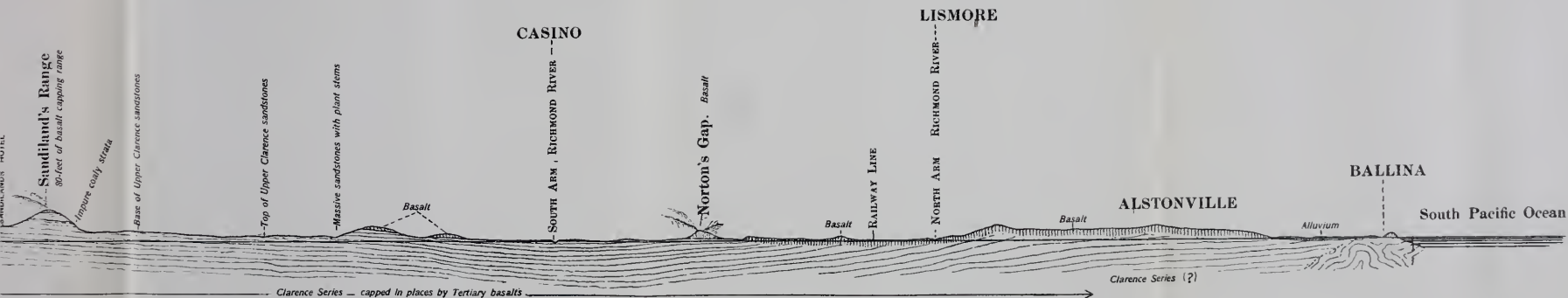


# SKETCH SECTION FROM TENTERFIELD TO BALLINA AS



# FIELD TO BALLINA AS REVEALED IN ROAD SECTIONS

Vertical Scale 0 500 Feet



Information for Section from Kettle's Lift to Ballina, supplied by J. E. Carne, F.G.S., Assistant Government Geologist.

# GEOLOGICAL MAP

With Section

## OF THE DRAKE GOLD FIELD

Geologically Surveyed by E. C. ANDREWS, B.A., Geological Surveyor, assisted by M. MORRISON, Field Assistant.

Scale 0 10 20 30 40 50 60 70 80 Chains

- I  Permo-carboniferous Strata Marine Beds
- II  Purple and green porphyries with breccias
- III  Older felsite series (aphanitic and banded felsites, tuffs, breccias and agglomerates)
- IV  Quartz felspar porphyry
- V  Green and purple felspar porphyries
- VI  Banded grey felsite
- VII  Grey and white banded and compact felsites with breccias
- VIII  Felsite lavas, tuffs, breccias, and agglomerates mostly of younger series (Often stratified)
- IX  Felsites, porphyries, breccias and agglomerates merging into purple and green porphyries
- X  Green felsite, typically non-porphyrific interstratified with Newer Series
- XI  Greenish grey columnar felsite
- XII  Green and purple agglomerates Newer Series
- XIII  Grey felsite
- XIV  Coarse granite of acid type
- XV  Felspar porphyry
- XVI  Light grey rhyolite breccia





